ENGINEERING

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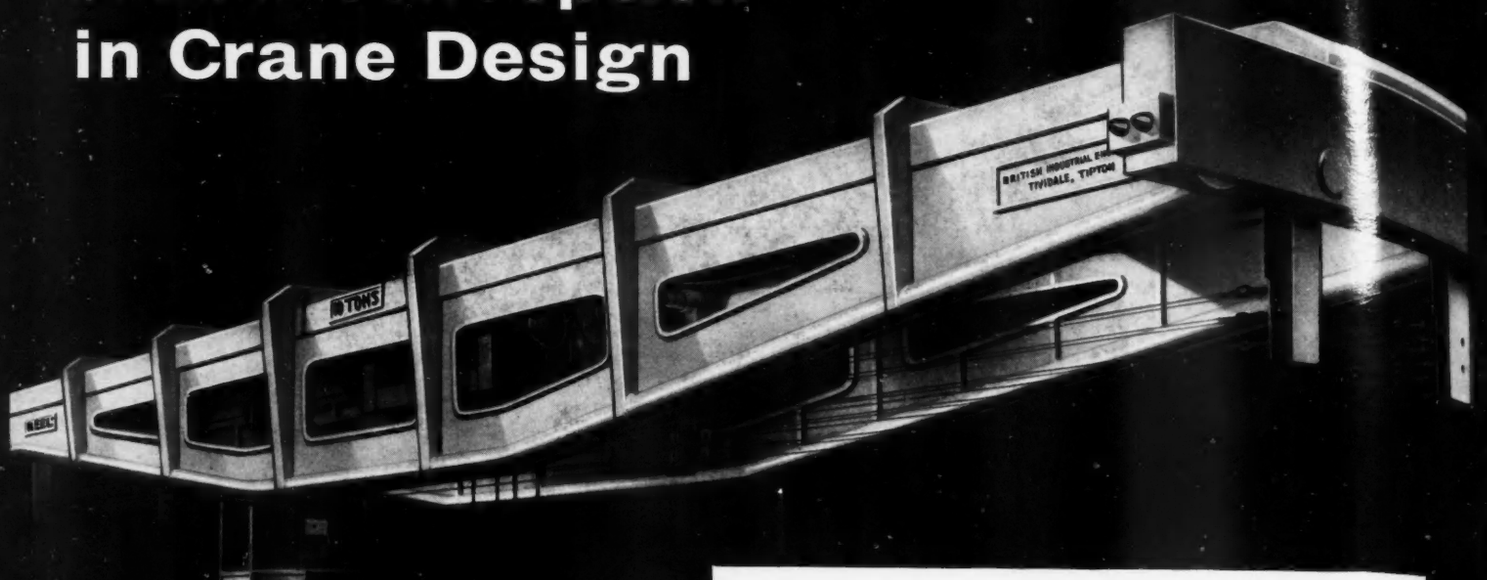
A new conception in Crane Design



THE BRITISH "REEL" OVERHEAD *Crane*

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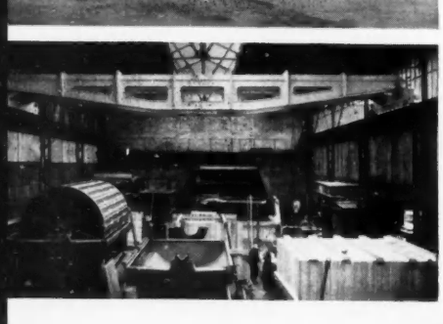

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Germany's Negative Bulge

THE figures for the number of children reaching the age of 15 in Western Germany during the next few years are disturbing. Just at the time when we in this country will experience numbers above the average—the widely publicised bulge—the German figures will be at a low ebb. Thus, while the apparent prospect of ample recruits to industry may tempt us to avoid the trouble and cost of further modernisation of plant, conditions in Germany will favour a more intelligent use of manpower and a greater degree of automation. Fortunately, our position is now generally recognised and preparations are being made at various levels to cope with the increased numbers of school-leavers.

But in relation to the position in Western Germany, the challenge remains. Within living memory the Germans have twice recovered their industrial poise after being shaken to the foundations of their economy. We know, too, from our own recent history as well as theirs, that nations invariably find ways of overcoming hard conditions but are easily duped by easy conditions. If we lived in a self-contained economy, our only serious worry would be the maintenance of full employment, but it is precisely because we compete with Western Germany in many world markets that we cannot afford to relax even when conditions might appear to favour relaxation. The Germans will have a redoubled incentive to be efficient. It is impossible to know the number of births in what is now Western Germany prior to 1946, but taking that year as a starting point, and without allowing for deaths in childhood, figures for the number of children reaching the age of 15 are obtained. Thus, 708,659 in 1961, 748,975 in 1962, 769,111 in 1963, 793,095 in 1964, and 772,850 in 1965. The bulge in Britain is spread over the three years 1961-1963, the number of children reaching the age of 15 rising to 929,000 in 1962, compared with an average of about 740,000 in the years before and after that period. This is a substantial increase.

In one sense the bulge should be a relief rather than a problem: the number of mouths to be fed and consumers to provide for will not change (the bulge children are already eating as much as adults), but there will be more hands and brains to do the work. As, however, the retired proportion of the population is increasing, one effect may cancel the other, and we shall be left with the problem of having an unusually large number of inexperienced workers. It could therefore be a stimulating opportunity to gain wider acceptance for new ideas in industry—so long as full employment is maintained. The present undercurrent of uneasiness about employment must be dispelled.

In the Soviet Union, recently published population figures show a lower total than had been expected. It appears therefore that the Russians, like the Germans, have a special incentive to be efficient, and in fact, their leaders and newspapers are waging a campaign for increased automation and productivity. Automation and mechanisation are to be discussed again at the annual meeting of the Communist Party Central Committee on 24 June. In yet another country—Sweden—it has been not so much the shortage of labour but the highest wage rate in the world which has encouraged remarkable improvements in productivity, particularly in shipyards.

Our own Government has already given a lead by appointing the Industrial Training Council last year, following the publication of the Carr Committee's report, and now by offering grants up to a total of £75,000 to industry in order to encourage apprentice-training schemes, provided industry contributes at least an equal amount. These sums, though not large should help offset the apparent reluctance of industrialists, to increase the number of apprentices. Even now, it is reported, 56 per cent of school leavers go into unskilled or semi-skilled employment.

In spite of these difficulties looming up in the next few years, the Trades Union Congress are taking an active interest in ergonomics and cybernetics. They have recently held a one-day conference for trade unions on "human engineering," and it seems only a question of time before union officials are sufficiently acquainted with these newer aspects of engineering to be able to prod unimaginative designers or thoughtless employers.

In industry, there is a plan to establish a National Control (or Automation) College. A scientific advisory committee of the Engineering Industries Association are working on this project, and hope to see such a college established at the existing College of Aeronautics at Cranfield.

These are signs that the urgent tasks are recognised. In retrospect, we can look back and say that we came through the fluctuating economic stress of the immediate post war decade more successfully and with less damage to the people than many had dared to hope. There is no valid reason now why we cannot similarly cope with this other consequence of a war's upheaval.

Cover Picture.—*The portraits of Cambridge men who have become presidents of the Institution of Electrical Engineers form a suitable background to an experiment into the magnetic properties of iron. Here teaching merges with research.*
(*Nurnberg photograph for* ENGINEERING)

Plain Words

What set me off this week was a remark I heard at a recent dinner. The speaker was talking about the current taste for foreign styling, particularly in cars: dismayed perhaps by the proliferation of Farinaceous coachwork, he proposed to get Picasso on the job. And why not? Art, we so often hear, has become remote from life; maybe it's time they got together once again.

What then is the kind of world we live in, the world we ask the artist also to inhabit? No longer is it characterised for most of us by the intricate configuration of an ear of corn or the dead and twisted remnant of a tree. We live in conurbations; we work in office blocks and factories; our pleasures are organised and manufactured. How could an artist come to love so passionless a world sufficiently to invest it with his recognition? When he has tried to do so the result has usually been sterile: impersonal caricatures of working men and a patronising emphasis on rust and smoke and furnaces. Perhaps it is our fault. We have scoffed at the painter for his abstraction, forgetting that abstraction is his job. Few artists, on the other hand, have taken any interest in the beauty that follows from utility and perfect functioning.

But beauty, like peace, is indivisible. Recognising this, a group of artists, architects and engineers in Germany set out before the war to found an institution where the claims of each might be integrated into a single organic whole. The Bauhaus, established in Weimar in 1919, and extinguished some 10 years later by the advance of Nazism, was one of the most enlightened and remarkable schools ever conceived. Enormously fruitful, it has left a heritage of influence in the best modern building and in the design of practical works from factories to diesel locomotives. Walter Gropius described the Bauhaus training in the following terms: " What the Bauhaus preached in practice was the common citizenship of all forms of creative work, and their logical interdependence on one another in the modern world. . . . . Therefore all alike, artist as well as artisan, should have a common training."

Of course this integration of art and engineering hasn't always worked out. I remember the Ford Motor Company asked a distinguished American lady poet, Miss Marianne Moore, to devise a name for their latest model. She applied herself diligently to the task and conceived a legacy of lovely names, combining the poetry of winds, exotic birds and fables. After several months and a long correspondence, the Ford company eventually wrote to her thanking her for her efforts, but advising her that a decision had been taken to choose a company name for the new car. It was to be called the Edsel.

CAPRICORN

Weekly Survey

Iron and Steel Constitution

Evidence has shown that the iron and steel industry, in contrast to coal, is pulling out of the recession. The better figures for both pig iron and steel output in March were further improved in April. Steel furnaces worked at 81·5 per cent of capacity during that month compared with 76·5 per cent in March. According to the Iron and Steel Board it is not possible to tell as yet whether this further increase in iron and steel production was due to an upturn in steel consumption or to a decline in the rate of stock reduction or to both.

Deliveries to home users in the first quarter of this year were 8 per cent higher than in the fourth quarter of 1958 but they were still 17 per cent below the rate of delivery achieved in the first quarter of last year. Deliveries have improved to the nationalised and investment goods industries except for the railways. Deliveries to consumer goods industries, including motor cars and canning continued at a high level. Generally, demand has improved for light steel products and to some extent for heavy sections, but there is no recovery as yet in the demand for plate.

According to figures for the first quarter of this year the iron foundry industry is also generally coming out of the recession. The increase in output in that quarter is the first non-seasonal increase to be recorded in any quarter since the middle of 1957. Output in the first quarter of 1959 was 1½ per cent higher than in the last quarter of 1958 but still 14 per cent lower than in the first quarter of 1958. Demand for castings from the motor vehicle industry was at a record level and output for the engineering industry was as good as in the last quarter of 1958. Ingot mould production has increased with the better steel figures and output for the building and domestic section was also slightly higher. Railway equipment production, however, still remains low.

World Steel Consolidates

For the past ten years the output of steel in the " free world " has risen steadily year by year to the record level of 287 million tons in 1957. Last year this triumphal progress was reversed and production fell by 29 million tons. Across the Iron Curtain in the Soviet bloc, however, production figures went on up. The immediate cause of the drop in output was the recession in the United States and Western Europe. In the United States half the fall in demand for steel is estimated to have gone into the running down of consumers' steel stocks. Another aspect of the situation was the improvement in the terms of trade brought about by the fall in raw material and foodstuff prices. This movement had its counterpart in lower demand in the steel importing countries.

In sharp contrast to this is the upward movement in the Soviet bloc. In 1958 China more than doubled its steel output as part of " the great leap forward " to industrialisation. It is to be expected that the Soviet bloc's production will continue to rise more rapidly than that of the free world. These countries are underindustrialised compared with Western Europe and North America. A high rate of increase is easier to obtain at their particular stage of development.

The Russian target of 86 to 91 million metric tons of steel by 1956 implies an annual rate of increase of 6½ to 7½ per cent compared with a rate of 11 per cent from 1948 to 1958. It looks as though the slow-down which is forecast in the expansion of the free world's output of steel is likely to be paralleled in the Soviet bloc, with the possible exception of China. Consolidation all round looks like being the keynote in the steel industry over the next few years.

Where to Put Reactors

Nuclear power has brought increased freedom in choosing power station sites. It requires little fuel and need not, therefore, be placed close to coalfields or good sea communications. On the other hand, it needs larger quantities of cooling water than the equivalent conventional station because of the relatively low thermal efficiency of present designs. As a safety precaution also, these stations are not placed near large towns. Nuclear power stations should be integrated into the electricity system economically and in consequence they make their most efficient contribution to the national electricity supply when sited in load areas hitherto dependent on imported energy. Such areas are the South of England, Lancashire and North Cheshire where there is no local coal or insufficient coal of low enough grade. To publicise these details the Central Electricity Generating Board has published a short pamphlet entitled *Siting Nuclear Power Stations*.

A nuclear power station of 500 MW needs 33 million gallons of water or 150,000 tons per hour—about twice as much as an equivalent coal-fired station. This requirement could not be met in dry weather by any river in the country and this puts a premium on coastal sites and large tidal estuaries. As a special case Trawsfyndd will use a hydroelectric reservoir. Water intakes must be always submerged but not silted up or damaged by storms.

Other important considerations are a soil substratum able to support heavy reactors, a flat site not much above high tide level and an area free from dangers of overcrowding with the station's buildings. Sites meeting all these requirements are not easy to find. The increase in the heat capacity of reactors has been sufficiently raised to allow the current nuclear power station programme, due for completion in 1966, to be accommodated on existing sites. Beyond that, technical advances may be less successful in overcoming the problems of geography.

Skimming the Surface

Mr. Donald Campbell's repeated successes in raising the world water speed record have created a spirit of emulation. This is part of the answer to those non-enthusiasts who have wondered why time and money should be spent in raising the water speed record steadily towards 300 m.p.h. Mr. Campbell established a new record of 260·35 m.p.h. although he achieved 275·15 m.p.h. in his outward run.

In the United States a scheme has now been announced by Mr. Guy Lombardo to build an American challenger along with the Aluminium Company of America. It is hoped to start trials in August, and if all goes well, to make an attempt on the record in October. A picture of the model designed by Mr. Staudacher shows a jet-propelled boat with a central cockpit and large sponsons projecting beyond the bow. The power unit will be the Allison J-35 jet engine used in the F-84 and F-86 American fighters. The boat will carry 9 spares in case one or more engines burn out. It will be 31·5 ft long with a skin of aluminium and a weight of 3 tons.

Interest in new types of sea-craft is not limited to breaking speed records. In the United States

the Curtiss-Wright Corporation has developed a prototype "Air-Car" which rides on a cushion of low-pressure air 6 to 12 in above ground or water. A propeller at the back sucks in air from an opening at the top. It can carry 4 passengers and travel forwards, backwards, sideways or turn in a circle.

Docks High and Dry

The Chancellor of the Exchequer rejected last week an amendment to the Finance Bill to give higher investment and initial allowances for dry dock construction and modernisation. This amendment, which was supported by members on both sides of the House, sought to obtain for dry docks the same allowances as are accorded to plant and machinery. The Dry Dock Owners and Repairers Central Council have publicly decided to continue to press for better taxation treatment of investment in dry docks.

So far as the Finance Bill is concerned the issue is one of interpretation. The Government no doubt take the view that a dry dock is no more a piece of plant and equipment than is any other kind of dock. On their side it has to be said that no known definition of plant and equipment includes a fabrication of reinforced concrete with ancillary equipment. On the ship repairers' side it has to be said that a dry dock is for them a piece of equipment. One way out of the impasse might be for the Government to make special provision for helping dry dock owners' to build dry docks with funds under the Distribution of Industry (Finance) Act 1958.

Export Credit Departures

A number of developments have been announced in the facilities offered by the Export Credits Guarantee Department. A new scheme is to be introduced shortly by which the department's 14 branch managers will be able to agree on terms for many buyers known to the department without reference to the head office.

Another innovation and one which will include engineering goods will be options to cover business on a three year basis compared with the present twelve month basis. Since ECGD will benefit by getting a bigger spread through time of export business, cuts in premiums of 5 per cent will be given to policy holders of three years standing who take out three year policies, and of 2½ per cent to other exporters taking out these policies

New policies are to be introduced covering special circumstances and for the construction industries An improved form of cover on stocks held overseas is also being introduced. Under the present system an exporter pays initially for six months cover whether stock is sold before this period expires or not. The new procedure bases the premium on the length of time for which the stock is held.

These announcements came at the end of a year to 31 March during which ECGD had reduced the rating schedules for short term business to give an average reduction of premium of some 6 to 7 per cent. During the year the department also covered 16 per cent of all United Kingdom exports compared with 14 per cent in the previous year.

Music Hath Frequencies

In this scientific age the problem of musical pitch has moved from the drawing room to the laboratory. Experiments have been carried out to ascertain the means by which a singer keeps his voice in tune and the degree of variation in pitch between instruments playing the same piece of music. A discussion on the subject was recently held by the Acoustics Groups of the Physical Society and reported by Professor E. G. Richardson, of King's College, Newcastle upon Tyne.

Experimental work has established how far fine variations in pitch can be detected, and work has been performed at the Institute of Experimental Psychology at Oxford on the means used by singers to maintain pitch. This work has suggested that the mechanism is a type of feed-back: that the sound produced by the voice is heard by the ears, compared unconsciously with the frequency and corrected accordingly. Experiments have suggested that a singer accustomed to his own voice responds more quickly to changes in frequency than he does to an externally produced sound.

The Acoustics Group discussion produced some interesting comments on experiments where electronically produced tuning notes had been used to check performances of pitch and intonation in different parts of recorded concert performances. Professor Richardson produced one example where in a Dutch tape-recording of Beethoven's first piano concerto the tuning was at 440 cycles (for A), to which the orchestra was able to tune to within one cycle. It has been found generally that pitch tends to rise in loudly played passages of music, possibly because the pitch of wind instruments tends to rise with blowing pressure.

Part Time Computer Advice

There have already been casualties in this country on computer consultancy work and some firms offering such services on a full time basis have not found it easy to obtain and keep clients. The trouble has been that most companies in this country which have become interested in installing data processing equipment have decided to hurry slowly. They have been impressed with reports of a number of organisations in the United States getting their fingers burnt by installing a computer over hastily; and caution has been reinforced by the considerable amount of expensive preliminary work in choosing the right equipment. It has been found extremely difficult by those offering a computer consultancy service to gear this cautious attitude on the part of clients, who think initially in terms of hundreds of pounds, to the need to keep expensive staff fully employed, where costs of many thousands may be involved.

A service to meet this problem has been planned by Urwick Diebold Limited, a new data processing firm formed in 1958 by two consulting firms Urwick, Orr and Partners Limited, in this country, and John Diebold and Associates Incorporated of the United States. The service is devised to offer assistance in the early stages of examining computer possibilities on a part-time basis and, therefore, at moderate cost. A fortnightly newsletter is also issued giving a digest of the latest data processing developments throughout the world. The scheme is thus an effort to spread a certain amount of highly skilled and expensive manpower over many comparatively small contracts.

Setting Store by Computers

The grocery and provision multiple concern, J. Sainsbury Limited, is to install an EMIDEC 1100 computer, made by EMI Electronics Limited. It is believed to be the first application of a computer to the stock control problems of a chain of provision stores in this country. The specification for the computer included ability to process a large amount of data in a limited time to enable the chain to operate a finer control system and so keep stocks at minimum levels while the chain continues to expand the number of its shops. The EMIDEC 1100 was chosen because of its large immediate access store together with its rapid input and output facilities.

The EMIDEC 1100 was designed as a commercial machine using cores and transistors. The use of transistors considerably improves reliability, eliminates the need for an expensive cooling system and cuts operating costs.

Letters to the Editor

STRESS RELIEVING

SIR, With reference to the article by Mr. J. C. Dixon on page 651 of your issue of 15 May, the low temperature stress relieving of welded platework is not as new as all that. A set of equipment, fully knocked down, was thrust into my hands as long ago as 1953, with no instructions other than to treat the bottom three rings of four 140 ft welded oil tanks at 375° F.

This was the time of the first low temperature notch brittle scare. Having to treat the tanks *in situ* multiplied the difficulties. There was no bottled acetylene and the consequent long run of pipe led to a dirty gas supply which repeatedly popped out. The size of the holes in the burners was exceptionally small (No. 75) and keeping them clean was a constant worry.

The problem of heating to the correct temperature was eventually solved by scribing two continuous lines with Tempilstiks on the other side of the plate being treated, for 350° F and 400° F. If both melted, the steel was too hot; if neither, too cold. But by keeping a man on the inside watching the crayon marks and using a knocking code to communicate with the operator an efficient routine was soon set up.

The objections to using the Tempilstiks on the same side as the flame as shown in your photograph are, firstly, that the flame melts it by direct radiation and, secondly, that the desired temperature attained on the outside does not necessarily mean that it is reached right through. A fast setting of the crab with high heat may leave the top hot enough but the inside too cool.

While the desirability of stress relieving welds in thick platework is fairly clear, one wonders whether it will develop into the latest fad and be extended to structural and pipework. Your photograph, for instance, shows a circular section being treated and one wonders whether there is quite the same scope for stress to build up as in plane platework.

Yours faithfully, H. W. STEPHENSON.
4 Grove Terrace, London, NW5.
23 May, 1959.

ENGINEERING UNITS

SIR, I read with great interest the 9 January issue of your journal ENGINEERING with the review of my book *Einführung in die Technische Thermodynamik*. However, I regret that the reviewer does not agree to the use of the International System of Units, and I doubt whether he is familiar with the new developments in this field.

The new system is already internationally agreed, also by England and the United States, and it has so many profits compared with the German Technical System (which is metric) or with the non-metric English system, that it finally will succeed.

The National Bureau of Standards in Washington already uses the International System for all its publications, and I beg you to contact your National Physical Laboratory, which also is changing to the new system, as far as I know.

However, it will need quite a long time for the final transition. But we have to consider that Russia, China, India and all the countries in development will immediately use the new system which convinces by its simplicity.

In our countries we also have to change and therefore I started and I am glad that Mr. Walter Traupel, whose book you refer to immediately after my own in the same number of ENGINEERING, followed me.

Yours very sincerely, ERNST SCHMIDT.
Technische Hochschule München.
19 May, 1959.

We regret that in the letter on standard symbols from Professor James Small, published in our issue of 1 May, the words "Institutions of" were inserted in line 13. The phrase should have read "whether it is now time for the civil and the mechanical engineers to do at least a little tidying up."

HIGH SPEED PHOTOCOPIER

100 Feet per Minute

THE Printmaster is claimed to be the fastest photocopier yet offered in this country. It runs at 100 ft per min.

The machine will accommodate materials up to 54 in wide and will stack prints at the front delivery up to 24 in by 54 in in sequence. Rear delivery stacks prints up to 42 in by 54 in face up. Below the top cover is a fluorescent lamp that enables the operator to view the quality of the prints being delivered to the rear stacking tray.

Illumination is supplied by a 9,000 watt mercury vapour lamp giving an intensity of 150 watts per in. The light intensity is variable from 5,400 watts to the full 9,000 watts to allow for adjustment according to the originals and the printing material being used. The power supply is stabilised to compensate for mains variations.

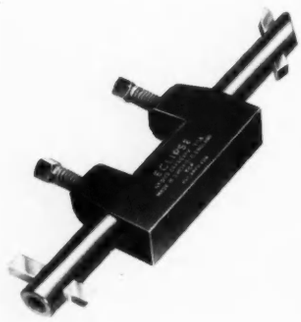
The jet injection ammonia system is synchronised with the machine speed to give the correct concentration of developer. There is also a manual control to allow for adjustment for special materials. All air entering the machine is filtered, and both lamp and cylinder are water cooled. The ammonia supply can be located at any distance from the machine up to 50 ft.

It is claimed that the feeding system is completely safe. On the entrance of any foreign body such as a pencil the pressure on the roll is disengaged immediately.

A pedal will release the tracing if it should be incorrectly fed in. To permit the recovery of prints before development, as when a double coated material is being used, there is a manual pick up control. *Ozalid Company Limited, Langston Road, Loughton, Essex.*

BORING TOOL HOLDERS

English Pattern Lathes



THREE multi-purpose boring tool holders, which have been designed for use on English pattern lathes, have been added to the existing range of Eclipse tool holders.

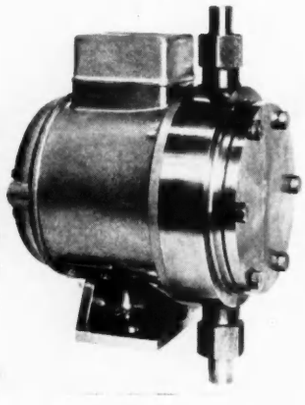
The cutter bar, which is rigidly held in a fixed B block by two clamping screws, can be positionally adjusted or removed without interfering with the setting of the holder itself. Furthermore, each holder is supplied with a double-ended type of cutter bar, in which the two cutter slots are machined at angles of 90° and 45° respectively; in both cases the cutter is held in position by means of an Allen grub screw.

The three sizes of holder are supplied with $\frac{1}{2}$ in, $\frac{7}{16}$ in and $\frac{9}{16}$ in diameter cutter bars respectively which, in turn, hold cutters that are $\frac{1}{4}$ in, $\frac{5}{16}$ in, and $\frac{1}{4}$ in square. In addition to holding the cutter bars with which they are supplied, the two larger holders will also grip securely the cutter bars which are supplied with those holders that are smaller; moreover, each holder will also accommodate all the four sizes of Eclipse boring bar (namely $\frac{3}{16}$ in, $\frac{1}{4}$ in, $\frac{5}{16}$ in and $\frac{3}{8}$ in diameter) as well as other tools, such as drills and reamers.

A further feature is the provision of two tapped and counter-sunk holes, complete with screws, on the underside of the holder for the purpose of facilitating the attachment of packings to suit any particular lathe centre height. *James Neill and Company (Sheffield) Limited, Sheffield, 11.*

NO-LEAK PUMP

Sealed Unit for Confined Spaces



THE latest addition to the Sigmund range is the Zero Leakage pump, a unit specially designed for operation where the nature of the liquid pumped demands there be no leakage whatsoever. It is also suitable for installation in confined and restricted spaces.

Constructed in stainless steel, the Zero Leakage pump is of the canned rotor type completely eliminating glands, mechanical seals and similar sources of leakage. The bearings are lubricated entirely by the pumped liquid.

The rotating element, mounted on a fixed stationary axle, is hydraulically and dynamically balanced. The end cover is removed to give access to the rotating element, which can be withdrawn without breaking the pipeline joints and without interference with the electrical connections.

The squirrel cage rotor is entirely shrouded by stainless steel, and the totally enclosed stator is suitable, in the standard design, for pumping temperatures up to 260° F (127° C). Special windings are available to permit pumping temperatures from sub-zero to 400° F (205° C).

With a branch size of $\frac{1}{2}$ in, the output is up to 8 g.p.m., and the pump will work against heads up to 60 ft. *Sigmund Pumps Limited, Team Valley, Gateshead 11.*

SIRIUS COMPUTER

£15,000 Unit for the Office

THE Sirius computer is a small general purpose machine for the office or factory where the volume of work is not very large. It is designed to fit a standard Roneo desk and costs £15,000.

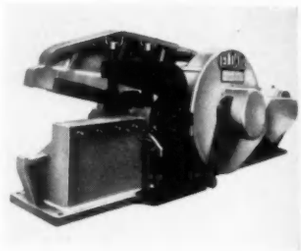
It is believed to be the smallest computer made in Europe. The weight is 5 cwt, installation takes less than a day and it plugs in to a 5A power point as the normal current required is only 3·8A, most of which, incidentally, is taken by the tape readers and puncher and the printer. It is understood that production models will differ slightly from the illustration in the layout of the control and indicating panels.

The reduction in size and the low current consumption have been achieved by the use throughout of transistors mounted in logical units or "neurons" in a somewhat similar manner to the plug-in board technique of Pegasus. Magnetostriction delay lines are used. The machine works in decimals, each decimal digit being represented by four binary digits. Checking is done inside the machine. Input and output are by paper tape, but information may be put directly into the main store (which has a capacity of 1,000 "words" of 10 decimal digits) by the use of buttons; the same buttons can also be used to operate the machine.

Sirius is expected to find its chief use in statistical analysis in industry, commerce and the laboratory; it is also expected to be used for educational purposes, and in the smaller divisions of large organisations. There is also a field for small work in large centres where it is undesirable to interrupt the work on a large computer. *Ferranti Limited, Hollinwood, Lancashire.*

SHEAR

Cuts up to $4\frac{1}{4}$ in dia. Mild Steel



THE Eldair model 3 alligator shear is a heavy duty machine with a capacity up to $4\frac{1}{4}$ in diameter mild steel rod on single stroke action or 3 in diameter on continuous running.

The machine has a cutting rate of 20 strokes per min and requires a 21 h.p. electric motor or a 29 h.p. diesel engine for the driving power. The capacity for some other shapes is: 15 in by 1 in bar on continuous action; 14 in by 4 in channel; or $3\frac{1}{4}$ in square bar on single stroke. The jaws open $9\frac{1}{2}$ in and the blade length is $29\frac{1}{2}$ in. The squeezer opening is 21 in.

The crankshaft, pivot pin and the gear shafts are alloy steel forgings, and the crankshaft and pin turn in phosphor bronze bearings. The pivot pin is adjustable horizontally and vertically to take up wear.

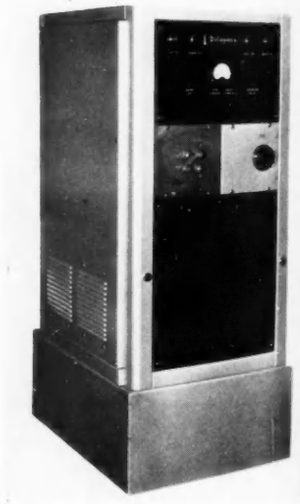
Compensation for induced thrust reaction when cutting is provided by a large steel wedge locating on a bronze facing, while in the connecting rod that links the crankshaft and the moving beam there is an overload shear pin for safety.

The high speed gears have machine cut double helical teeth and the high speed pinion shaft is journalled in ball bearings. Crushing jaws at the end of the blades deal with bulky material.

The machine is controlled by a pedal that operates a multi jaw clutch which can be set for either single stroke or continuous cutting action. An automatic brake ensures that the machine stops when the clutch is out of engagement. The shear measures 14 ft 9 in by 4 ft 6 in by 5 ft overall and weighs approximately 11 tons. *George Cohen, Sons and Company Limited, Wood Lane, London, W12.*

INDUCTION HEATERS

Intermittent Rating of 12 kW



THREE induction heater generators with continuous ratings of 9 kW can be run at 12 kW intermittently. They differ in the impedance characteristics of the r.f. circuits and in the provision of power control.

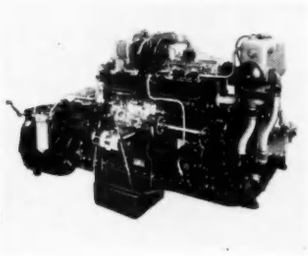
Each model has two pairs of output terminals which are connected in parallel for loads of comparatively low impedance; for loads of higher impedance they are connected in series. A pair of paralleling plates and a series link are included in the equipment. Boost condensers are fitted internally and can be brought into use (for increasing the kVA circulating in the coil) by a link.

Two of the models are fitted with an on-load current control which allows continuous regulation of the output power over a 10 : 1 ratio during the heating cycle.

Model HC is the most suitable for general work and for high impedance samples; model LC for low impedance; and model H (which has no output control) for high impedance work and for soldering or brazing. *Delapena and Son Limited, Tewkesbury Road, Cheltenham, Gloucestershire.*

MARINE DIESELS

200 h.p. at 1,750 r.p.m.



MARINE versions of the Thornycroft RKRN6 engines are now available in normally-aspirated and supercharged models.

Bore and stroke are 4¾ in by 6½ in, giving a cylinder capacity of 691 cu. in (11·33 litres). The compression ratio of both models is 16 : 1. The maximum continuous power rating of the normally aspirated model is 125 s.h.p. at 1,600 r.p.m., rising to 145 s.h.p. at 1,750 r.p.m. for intermittent operation. The corresponding figures for the turbocharged model are 160 s.h.p. and 200 s.h.p.

The cylinder block is a chromium iron casting with dry cast iron liners. Two interchangeable cylinder heads each cover three cylinders. The pistons are tin plated aluminium alloy with three compression and two oil control rings, the top ring being chromium plated. A toroidal combustion chamber is formed in the piston crown.

The connecting rods are alloy steel forgings with bronze bushes in the small ends and strip type copper lead shells in the big ends. They can be extracted through the cylinder bore. The crankshaft is nitrided and runs in seven copper lead lined main bearings; a viscous damper is fitted to the forward web. The crankcase is a chromium iron casting.

Forced lubrication is supplied by a high output gear pump and the engines are fitted for fresh water cooling as standard. A Simms-Eberspacher turbocharger is used. The normally aspirated model weighs 3,400 lb including reversing gear, and the supercharged model is 475 lb heavier. The maximum angle of installation for either is 1 in 5 (11½°). *Thornycroft Limited, Thornycroft House, Smith Square, London, SW1.*

GAS LIQUEFIER

For Cooling Circuits and Systems

FOR the smaller user who wishes to have a supply of liquid air or a cooling system with temperatures down to — 160°, the Philips type PW7000 gas liquefying machine has been introduced.

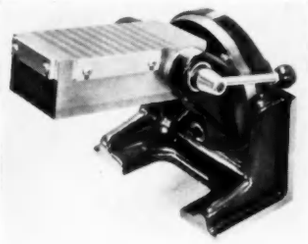
Among the chief claims are the speed of production of liquid air (less than 15 minutes from a hot start) and the very small power consumption, a 10 h.p. motor is sufficient to produce 5 litres of liquid air per hour (1·1 gal). With the standard equipment the machine will run continuously for up to 23 hours before the air dryer becomes blocked by ice. Protective devices in the control system allow the machine to run unattended. The air dryer can be defrosted in 45 minutes, for which purpose ancillary equipment is available.

The machine operates on the displacement principle using hydrogen as the working fluid. The heat generated by the compression is removed by a flow of cooling water at the room temperature. Being on a closed cycle the only hydrogen demands are for a very small make up to counteract leakage.

Air, or whatever gas it is that is being cooled, enters the dryer, which is in thermal contact with the cooling head, and water and carbon dioxide are extracted. The air then condenses against the outside of the head and is drawn off as liquid. Alternatively, cooled air can be circulated to a freezing chamber for such purposes as cold hardening of steel. *Research and Control Instruments Limited, 207 Kings Cross Road, London, WC1.*

MAGNETIC CHUCKS

Ranges of Sizes and Accessories



A RANGE of Fimex magnetic chucks and accessories is now being produced by Darwins of Sheffield.

The example illustrated is the universal model in which the rectangular chuck can be tilted to any angle required. The angle can be set by the circular scales or by using a sine bar or other means; once set the chuck can be locked in that position.

The base can stand on either face, increasing the flexibility of the unit. The operating lever can be moved to either side of the chuck and is also variable in position so that it does not interfere with the work at all.

The chuck itself is mounted in high grade iron castings which are hardened and ground on the working faces, and ribbed for strength. The working surface is 7 in by 3 $\frac{3}{16}$ in and the base area is 8$\frac{5}{8}$ in by 6 in maximum and the minimum height is 4½ in.

Two types of rectangular chuck are included in the range; the D type which is characterised by a low overall height; and the F type which has a high gripping power. The latter type is also suitable for use in gangs, and can be used for side gripping. Dimensions of the F type range from 7 in by 3 $\frac{3}{16}$ in to 24½ in by 19½ in. The D type ranges from 10 in by 5 in to 24 in by 12 in.

Accessories available include two adaptor blocks, one of which is rectangular and can be supplied as a V block or profiled as required, and the other a tilting block for direct mounting on a flat chuck. Three sizes of the former are made, ranging from 4¼ in by 2½ in to 12¼ in by 2¼ in. The tilting block measures 4¼ in by 3 $\frac{21}{32}$ in. *Darwins Limited, Fitzwilliam Works, Sheffield, 9.*

FRACTIONAL H.P. MOTORS

To Nema and British Standards

THE T45 range of fractional horsepower motors which go from $\frac{1}{20}$ h.p. to ½ h.p. three phase and from 1/40 to ¼ h.p. single phase, are built to Nema standards. Running speeds are 960 r.p.m. for the smaller sizes and 1,425 r.p.m. for the larger.

Technical improvements for these motors include smaller winding slots; more evenly stressed magnetic material with consequent reduction in core size; pressure die cast windings; large cooling fins which also act as fans for the stator windings; and polyvinal acetyl resin insulation on the stator.

Other features claimed are a roomier terminal box and a stiffer end bracket. For mounting driven equipment on the motor there are four tapped projections on the driving end shield which can be machined to provide a spigot. Alternatively through-bolts can be used.

In order to comply with Nema standards the motors have a ½ in diameter shaft extension. The bearings, however, are ⅝ in diameter which allows ⅝ in shafts to be provided at either end of the machine at extra cost. The motors also comply with B.S. 1608 and can be used for refrigeration duties; the temperature rise on drip proof machines is well within the permitted limits. In general the motors comply with B.S. 170.

The range makes provision for seven methods of mounting, including solid foot, resilient, end-face and oil burner flange. On the foot mounted versions the shape of the steel foot has been designed to make it as rigid as heavy cast iron. *Crompton Parkinson Limited, Crompton House, Aldwych, London WC2.*

SCREWDRIVER

For Hose Clips

THE manufacturers of the Jubilee wormdrive hose clip have produced a special non-slip safety Jubilee Clipdriver.

Apart from the fact that when clips are being applied in awkward situations there is the danger that an ordinary screwdriver may slip, it is often necessary to make the screws very tight to withstand high pressures. The tool, simple in conception and design, is made of bright cadmium plated mild steel and has a spring-steel tongue insert to engage in the slot of the screw head. A sleeve extended over the insert fits around the screw head and prevents slipping. The T bar is set at an angle to the main shaft of the Clipdriver to prevent the application of a large tube or socket spanner.

The Clipdriver is designed to fit Jubilee clips only and is made in one head size, as the screw slot in the Jubilee range is standard for all sizes. It is however made in two lengths, 6 in and 3½ in, to suit various situations. *L. Robinson and Company (Gillingham) Limited, Gillingham, Kent.*

CONTRACTORS PUMPS

Compressed Air Diaphragm Operated

CLAIMS for the Layton diaphragm pump are that it is light, small, compact, and explosion proof.

The standard model weighs only 65 lb and measures 22 in high by 12 in in diameter. It can therefore easily be handled by one man and can be introduced into small apertures. It will operate against heads of 100 ft or more.

The pump is self priming and will handle liquids containing a high percentage of solids or abrasive matter. These pass through without coming into contact with the moving parts. A metal strainer, which forms the base of the pump, prevents any oversize material from entering. The strainer can be removed and a length of hose substituted when the pump is operating above water level.

Since it is operated by compressed air the pump is safe to use in concentrations of dangerous gasses; the air consumption is said to be small. *Henry Sykes Limited, 53b Southwark Street, London, SE1.*

At the BUSINESS EFFICIENCY EXHIBITION *Olympia, London 25 May to 4 June*

Most engineers are agreed in disliking paper work. It would seem therefore to be up to them to make the nuisance as bearable as possible by ensuring efficiency and cutting out the donkey work. Incidentally the more machines they can introduce to the office the bigger the outlet for their design ability and the wider the field for production—and employment.

Britain is said now to be the second largest producer of office equipment in the world. Some idea of the scope can be gained from the items on show at Olympia, ranging from a major size computer to a sticky label, and including "auto-typist" machines, four of which can be operated by one person to produce 500 individually typed letters a day. In all, over 135 firms are taking part in this, the 46th, exhibition, which is organised by the Office Appliance and Business Equipment Trades Association.

CALCULATORS

Punched Cards and Data Processing

THE type 1202 computer is a medium-sized electronic machine which provides a comprehensive data processing system. It has magnetic drum storage, with a capacity of 4,096 locations, and 80-column punched card input. Output is direct to a card punching unit and a printing tabulator.

In the 21-column range of calculating machines there will be a new tabulator with coupled summary card punch, which can handle a wider range of accounting work than has hitherto been possible with this series of machines. A 40-column installation will demonstrate a variety of accounting applications, including the use of the Emp Electronic Calculator.

A variety of 80-column machines will include the type 555 Electronic Calculator demonstrating stock accounting with automatic price averaging, and the 902 Tabulator. *International Computers and Tabulators Limited, 17 Park Lane, London, W1. Stands Nos. 69 and 74.*

DUPLICATOR AND COPIER

Documents and Photographs

THE Bandamatic is a spirit duplicator with special features.

It will reproduce from typing both full copies at high speeds of operation and will also extract automatically single items or groups for appropriate documents, while retaining such information common to the full list as may be necessary; for example, the customers order number and name. It is the first time that this machine has been exhibited in London. One particular use is for part order deliveries. A single master sheet will produce up to 300 copies. Spirit duplicators can use up to 7 colours in one operation.

Another machine is the Bandavelop which is used for book and document photocopying. It is said to make copies of photographs of half tone quality, producing an aluminium offset plate ready for printing in less than a minute from any original. *Block and Anderson Limited, 58 Kensington Church Street, London, W8. Stand No. 24.*

REPRODUCING DRAWINGS

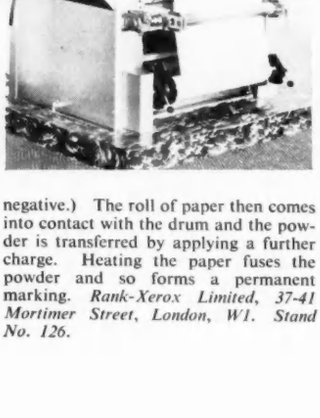
Microfilm Xerography

THE Copyflo 5 prints engineering drawings from microfilms filed on punched cards by xerography on to cheap unsensitised paper.

The unitised microfilm system makes use of the three modern techniques of recording drawings on microfilm, storing them on punched cards for quick location and printing them by xerography when copies are required. Continuous rates up to 20 ft per min are standard.

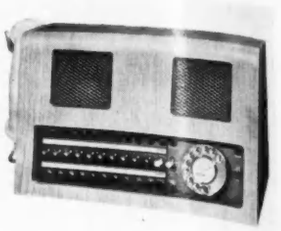
Drawings are recorded on 35 mm film in the usual way, but instead of the film being kept in continuous rolls, each frame is mounted in a Filmsort punched card which measures about 7½ in by 3¼ in.

When a reproduction is required the card is inserted in the projection head of the machine and the image thrown on to a revolving selenium drum that has been charged by passing a wire grid. Powder is then scattered on the drum and adheres to those areas where the charge has not been dissipated by the light from the projection. (The process is reversed when the original is a negative.) The roll of paper then comes into contact with the drum and the powder is transferred by applying a further charge. Heating the paper fuses the powder and so forms a permanent marking. *Rank-Xerox Limited, 37-41 Mortimer Street, London, W1. Stand No. 126.*



INTERNAL TELEPHONES

Choice of Systems



A RANGE of telephone systems exemplify Siemens Edison Swan products. The Intermatic master station is illustrated.

From the master station the line keys on the front of the panel link up with 10 or 20 side stations, each of which can, in turn, be linked to 5, 10, or 15 other side stations by keys. On the master unit the automatic dial switch allows access to other master stations or to the main switchboard, while an automatic switch on the side station unit will give a line direct to other networks. The system is therefore adaptable for growth and extension.

Two unusual types are the "deaf-aid" and the "silent call." The latter is intended for such positions as broadcasting studios where silence is essential, and therefore has the warning bell replaced by a flashing lamp protected by a perspex cover. The "deaf-aid" can be used directly as its name implies, or in very noisy situations to overcome interference.

Loudspeaker contact between two or more positions in the same building is offered by the Callover system. It can be used independently of any other telephone installation and consists of a master unit linked to one or more sub-units. Conversation between any two cannot be overheard by a third and the volume of sound reproduction can be adjusted by a control on the side of the master unit. *Siemens Edison Swan Limited, 155 Charing Cross Road, London, WC2. Stand No. 49.*

MAGNETIC CORE CALCULATOR

150 Cards per Minute

THE IBM 628 magnetic core calculator is said to combine the simplicity of a control panel calculator with a large storage and programme capacity.

It is designed to work with a card printer and the high-speed 421 accounting machine. Its input/output capacity is at the rate of 150 cards or 150 lines of print per minute. It has an electronic storage capacity of 320 digits. Average addition time is 180 microseconds. There is a programme of 160 steps with high speed programme skip forwards and backwards. Electronic selectors can be picked up during the high speed programme.

The IBM 610 automatic decimal point computer is a mathematical calculator which can programme itself. The calculation is performed by depressing the appropriate operation keys. The result is automatically typed, alignment of decimal points being fully automatic. *IBM United Kingdom Limited, 107 Wigmore Street, London, W1. Stand No. 106.*

TYPEWRITERS

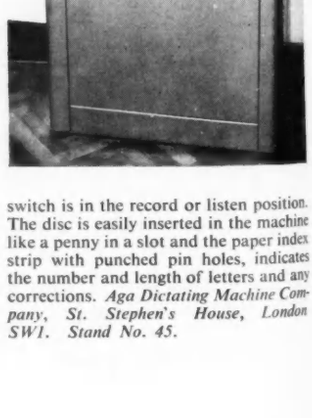
Manual and Electric

THE Stateseman electric typewriter employs the proportional spacing principal in which each character is allotted space according to its width, giving the appearance of printing. The machine is said to be capable of very high speeds without jamming of the type bars. A new device has been fitted to give instant setting of the margin stops, and the accurate justification of the right hand margins has been simplified. The machine has a "speed slope" keyboard with 44 characters and there is a choice of type styles.

Also exhibited is an electric typewriter synchronised with an 80-column Hollerith reader. The data from the punched cards is produced at the rate of 480 characters per minute. "Slave" typewriters can be linked to the reader. An attachment for a standard typewriter facilitates the production of Addressall stencil plates. *Remington Rand Limited, 12-14 Clipstone Street, London, W1. Stand No. 109-120.*

DICTATING MACHINES

Centralised Installations



THE centralised installation of dictating machines, in which several machines are placed together in one room and the messages are dictated to them over the telephone, is growing in popularity.

The Agavox Teledictation system is available in two forms: with separately wired push-button telephones or using the dial telephones of an existing private automatic telephone installation. With the latter, little or no alteration is necessary to the telephones or the exchange equipment. By dialling the figures 1 to 6, the dictator has complete remote control of an Agavox in the typing department. The discs have a life of at least 20,000 recordings.

The Model C dictating machine incorporates full controls on the microphone as well as simplified telephone recording. All that is necessary is to press a key on the right hand side of the machine and both sides of the telephone conversation will then be recorded irrespective of whether the microphone switch is in the record or listen position. The disc is easily inserted in the machine like a penny in a slot and the paper index strip with punched pin holes, indicates the number and length of letters and any corrections. *Aga Dictating Machine Company, St. Stephen's House, London SW1. Stand No. 45.*

WAITING FOR A TELEPHONE

Capital investment in the Post Office telephone service was the subject of a recent debate in the House of Commons.

Mr. William Shepherd (Conservative), who initiated the discussion, felt it to be an incredible state of affairs that fifteen years after the war, in a period in which there had been a relative degree of freedom for capital expenditure, the Post Office could only look forward to continuing to disappoint their customers. He knew, of course, of the Herculean efforts that the telephone service had made during the last few years and was aware that the number of persons on the waiting list for telephones had been reduced from 500,000 to 150,000, but the fact remained that 150,000 people who wanted telephones did not have them.

In the public section of industry, there had been a very considerable growth in the level of capital expenditure. The expenditure of the National Coal Board had increased enormously. A great deal of money was to be invested in the railways, a means of transport which a lot of people did not want to use, and the Central Electricity Authority was to have an enormous increase in capital expenditure. Yet the one public service for which there was a steady and increasing demand was to have its capital expenditure reduced.

A supporting speech was made by Mr. John Edwards (Labour), who said that, looking at the Post Office solely as a business enterprise, it was foolish, especially in the present circumstances, not to provide a larger capital programme. According to the *Economic Survey for 1959*, the gross fixed investment in the public sector of industry, ranging from the Coal Board to the Government and local authority sections, would amount to a total of £1,449 million in 1958-59 and to £1,607 million in 1959-60. The corresponding totals for the Post Office, however, were only £98 million in 1958-59, and only £94 million in 1959-60. The Post Office was a profitable enterprise. It was, moreover, an enterprise which could obtain a greater demand if it went out for it.

The Government's considered opinion was that the national economy needed stimulating. Here, in the Post Office telephone service, was a case in which investment could be stepped up with good secondary results in the manufacturing industries, which provided all the equipment.

TOO FEW YOUTHS IN TRAINING

A tribute was paid by Mr. Shepherd to the Post Office's engineering staff. He believed that the Postmaster-General employed more skilled men than any other Government department and pointed out that in a recent debate both sides of the House of Commons had lamented that the number of men being trained as apprentices was getting smaller instead of larger. The Post Office ought to be taking more apprentice workers and training skilled men, but, instead of expanding its force to meet the public demand, the department was having to put on the brakes.

This point was supported by Mr. Edwards, who referred to the appeal of the Ministry of Labour to " all firms " which were not training apprentices at present " quickly to make plans to do so." Yet here was one of the most important State departments curtailing its recruiting. The loss could not be made up later, because the age composition of the labour force would be badly out of balance.

In reply, Mr. Ernest Marples, the Postmaster-General, agreed that the Post Office engineers had done splendid work. They were, he stressed, civil servants and that, quite rightly, gave them security. There was, however, a price to be paid. In the Post Office, one had a relatively rigid labour force compared with other enterprises. The department recruited to a permanent labour force and if too many people were taken in the difficulties were made greater. Officials of the Post Office had a delicate task in trying to weigh the amount of recruitment necessary against the probable amount of capital investment. If too many persons were recruited, the department might be in great difficulty unless it could resort to a " hire and fire " basis. That was a savage dictum which he would not like to see used.

MORE MONEY ON ADVERTISING

Rightly or wrongly, Mr. Marples said, the principle in the public sector of industry was that departments could not do as they liked. The Government decided, first, the level of investment which the country could afford, bearing in mind the resources of industry, the savings of the people, the Budget surplus, and the need for a secure pound.

The amount having been decided, the Treasury had to apportion it between competing needs. These were many: hospitals, roads, railways, housing, education, the Post Office, electricity, coal, gas, and all the rest. A good case could be made for increasing the allocation to each of them. He could make a good case for the Post Office. He agreed, too, that there was a difference between a revenue-producing concern like the Post Office and one which took its money entirely from taxation.

He considered that, when roads were being built, any telephone cables required should be laid at the same time. Automatically, therefore, investment on the telephone service should be increased when the investment on roads was increased. He hoped soon to show that the department had gone to great lengths to produce value for money. Much thought had been given to the construction of buildings, such as telephone exchanges, and there had been a quite startling change in value for money.

Wages amounted to a steady charge on capital investment and the department's employees could not be " fired " at a second's notice. Consequently, the Post Office gave its contractors a rather rough time by imposing savage cuts, or making increases, according to alterations in its capital investment. It was true that there was a hard core of 60,000 people waiting for a telephone, but its composition was constantly changing. In some places, people could get a telephone tomorrow: in others, it was more difficult.

In a circular issued by the Post Office Engineering Union to all members of Parliament, it had been stated that the level of investment had been restricted in an arbitrary fashion. That was not so. The investment level was settled after the Government had carefully weighed the needs of the Post Office against those of other public bodies.

It had been said that the Post Office did not advertise. In fact, the department had spent more money on advertising in the last two years than in the previous three.

Shipbuilding Orders Decline

The level of new orders for merchant ships received by shipyards in the United Kingdom during the past year had declined, Mr. Thomas Galbraith, the Civil Lord of the Admiralty, told Mr. W. W. Hamilton (Labour). The Government were aware of the anxiety which this decline was causing, but the level of orders was not likely to rise appreciably until there was a recovery in world trade.

Technical Assistance to Other Countries

Questions about British assistance being given to other countries under the terms of the International Labour Organisation's Technical Assistance Programme were put to the Minister of Labour by Mr. R. E. Prentice (Labour). In reply, Mr. Iain Macleod said that between 1954 and 30 March, 1959, nearly one hundred worker trainees had received training in the United Kingdom under the Organisation's projects. From 1951 to 30 March, 1959, nearly 150 British experts had taken part in such projects. Many of these experts had assisted in more than one project.

Krupp's German Interests

Asked by Mr. Edward du Cann (Conservative) about the deconcentration of the German iron and steel industry, Mr. D. Ormsby-Gore, the Minister of State for Foreign Affairs, said that all the required deconcentrations had been carried out, except a small portion relating to the former firm Vereinigte Stahlwerke and a larger portion relating to the firm of Krupp. In respect to these, a Mixed Committee was being formed under the provisions of the Bonn Settlement Convention, to consider applications for an extension of time in which to carry out the remaining sales. The British member to that committee had already been nominated.

Cheques for the Manually Employed

Mr. Iain Macleod, the Minister of Labour, informed Mr. Graham Page (Conservative) that his national joint advisory council had accepted the view that wages might, at the request of the worker and with his employer's agreement, be paid into the workers, bank account or by cheque; and, in certain circumstances, be paid by postal or money order. The Council recommended that a committee should be set up to review the operation of the Truck Acts, and to make suggestions for bringing the Acts into line with modern conditions. These suggestions were now receiving the attention of the Government.

Housing Standards Inquiry

A desire was expressed by Mrs. Joyce Butler (Labour-Cooperative) that the Minister for Housing and Local Government should order an inquiry into housing standards, with particular reference to private houses of less than the minimum standard for local authority dwellings. Mr. Henry Brooke replied that, at his request, a subcommittee of the Central Housing Advisory Committee had recently started to make a review of housing standards. The review would cover privately-built houses as well as houses provided by public authorities. The task was a large and difficult one and would take time to complete.

MEETINGS AND PAPERS

Association of Supervising Electrical Engineers
LONDON
Annual General Meeting. North London Branch. Town Hall, Wood Green, N22. Wed., 3 June, 7.15 p.m.

Chemical Society
LONDON
Various short papers for reading and discussion. Thurs., 4 June, 7.30 p.m.*

Helicopter Association
LONDON
"Some Design Aspects of Tandem Rotor Helicopters," by J. D. Sibley and C. H. Jones. Royal Aeronautical Society, 4 Hamilton Place, W1. Fri., 5 June, 6 p.m.

Institution of Civil Engineers
LONDON
Annual General Meeting. Tues., 9 June, 5.30 p.m.*

Royal Institution
LONDON
"Origin of Particles of Great Energy in the Cosmic Radiation," by Professor C. F. Powell. Wed., 3 June, 8 p.m.

Royal Society
LONDON
Various short papers for reading and discussion. Thurs., 4 June, 4.30 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927.)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, SW1. (ABBey 5160.)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577.)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W1. (REGent 3335.)

Welcome to Milford Haven

The " Milford Haven Project " has a romantic ring to its name. The picturesque background of the Prescelly Hills and the deep calm waters of the haven confirm the visitor's impression that this is something quite out of the ordinary. The details of the project, its immense scale and the fantastic suggested potential further underline the impression that " an enormous industrial facelift is slowly taking place." In a relatively short time it could be transformed from Britain's fifth largest fishing harbour into one of the busiest and best equipped seaports in Europe. In fact this is the inevitable outcome of what is now taking place.

A Scottish industrialist, Mr. Tom Scott Sutherland, has commissioned a film which is intended " to spotlight the marine and industrial potential " of this South Wales seaport. The producer is Mr. Charles B. Dean, who is managing director of Hartley Ward Films and one of the best known industrial documentary makers. The film, which is being shot now, will be completed by the end of July.

There are so far three main commercial organisations actively engaged in the area. The British Petroleum Company are constructing a pier to take two of the largest tankers alongside, discharging into a pipeline to their Llandarcy refinery. The Esso Petroleum Company are building a refinery on the shores of the haven and a jetty, also able to take the largest tankers afloat. Both the BP and the Esso schemes are expected to be completed during 1960, and will have a combined intake of crude oil of some 9½ million tons a year. The Angel Ore and Transport Company, owned jointly by the Steel Company of Wales and Guest Keen Iron and Steel Company Limited, have planned to build a large jetty, which would be able to take the biggest ore carriers afloat. They will enter the haven to discharge, and their cargoes will then be reloaded into smaller craft which are able to navigate the shallower waters of the river and estuaries of the United Kingdom and the Continent of Europe.

These three schemes alone are expected to provide Milford Haven with 20 million tons deadweight of shipping a year. But there are several other projects, including expansion of the dry dock and ship repair facilities operated by the Milford Haven Company, a substantial increase in the Milford trawler fleet, the building of oil storage capacity by the Milford Haven Storage and Pipeline Company (up to 300,000 tons) connected by pipeline to further tank storage situated near Birmingham which together will provide Milford Haven with a total of a million tons of storage.

Air and rail services between Milford Haven and London are being improved (including a sleeper express) and plans are well advanced for the building of a 150-bedroomed hotel on the site of Hubberston Fort. The development of services and further industrial projects are expected to gather momentum now that a major start has been made to the haven industrialisation. Recently elected chairman of the Milford Docks Company, Mr. F. G. Mitchell, is also chairman of the Mitchell Engineering Group, who are actively interested in the construction of an atomic submarine tanker (the Moby Dick, designed to open up the ice-locked Hudson Bay during the winter). Milford Haven would be an ideal European terminal for the venture.

Tupolyev and Ilyushin

The first scheduled flight to Moscow was inaugurated last week by the Viscount Aircraft " George Stephenson " of British European Airways. The company's chairman, Lord Douglas of Kirtleside and Lady Douglas, Mr. John Hay, parliamentary secretary to the Ministry of Transport and Civil Aviation and Mrs. Hay, together with several members of Parliament and businessmen, left London Airport at 0950 hours and arrived at 1640 hours. Towards the end of this year BEA expect to take deliveries of six Comet 4B jet airliners which will cruise at 545 m.p.h. and give the company parity in speed with the TU104 jets operated by Aeroflot.

The Soviet Union will from now on have a major stake in the fast growing international air transport business. Already Aeroflot fly into 20 foreign countries and have greatly expanded over the past four years. They operate all of Russia's international air services and 80 per cent of the internal routes, a total network covering about 225,000 miles, and claim to be the world's largest single air transport operator. The TU104 is the standard Soviet airliner on routes outside Russia, and the improved TU104A and TU104B versions are increasingly coming into use. Several new civil aircraft have been developed over the past two years. One of the most impressive is the Ilyushin 18 Moskva, which cruises at 400 m.p.h. and can carry 75 to 100 passengers. Another four-engined turboprop machine is the TU114 Rossiya, which the Russians say is the world's largest aircraft, able to carry up to 220 people and cruise at between 435 and 500 m.p.h. It will be used for non-stop flights from Moscow to New York (if the Americans allow it), Tokio, Peking and other distant capitals. The Moskva was recently offered to Sabena for $1 million, a sum less than half the price of the American Lockheed Electra or the British Vickers Vanguard, which are comparable aircraft.

Aeroflot have a long way to go before they become established as an international airline operator. A vast maintenance and service system will have to be built up at the main airports and new standards of passenger comfort and handling will have to be adopted. Nonetheless, a start has been made, and it is a forceful one.

German Steel Recoalesces

Before the war over half the German steel industry was controlled by the Vereinigte Stahlwerke which the Allies broke down into 17 companies as part of their deconcentration policy. In the past few years these 17 firms have been gradually changing their composition and at the present time nine of them account for 90 per cent of West German crude steel output. The future pattern that now seems to be emerging is one in which three firms will operate the complex of coal and steel interests formerly belonging to the Vereinigte Stahlwerke. These are the Rheinische Stahlwerke which incorporates the Krupp steel making interests, and the Dortmund-Hörder Büttenunion, both with an annual capacity of about 4 million tons of crude steel. The third concern is now in process of formation. It is the result of a merger between August Thyssen Hütte and Phoenix Rheinrohr and will require the approval of the High Authority of the European Coal and Steel Community.

Apart from this coalescing of the elements of the Vereinigte Stahlwerke there are several other very big concerns operating in German steel. The largest is the state-owned Hüttenwerk Salzgitter. But a move towards concentration now going on will shortly produce an even bigger giant. This is the merging of Mannesmann, Hoesch and Klockner. By the time this move has been carried through the German steel industry will have reached a point where any further mergers will produce monolithic structures compared with which the old Vereinigte Stahlwerke was a mere stripling.

Winged Arrow in a Circle

Skoda works in Plzen in Czechoslovakia, celebrates its hundredth anniversary this year. It began as a small engineering workshop founded by Count Waldstein in 1859 for the manufacture of steam driven factory equipment. Ten years later, in 1869, it was bought by a young engineer, Emil Skoda. Thereafter it developed rapidly and by the end of the century already occupied an important position in Europe's engineering industry. After the First World War the range of products was extended to include heavy electrical plant (turbines and turbocompressors were already being made) and transport engineering, including locomotives, road vehicles and aircraft. A reputation was built up for the supply of complete industrial plants. Crisis came in the 1920's and the works were completely destroyed during the last war.

Since the war the former joint stock company which merged numerous enterprises with various production programmes throughout Czechoslovakia, was divided into independent national corporations. The original plant of the Skoda works at Plzen was preserved and remains a fully integrated steel and heavy engineering production plant. The metallurgical and engineering works have been completely reconstructed since the war and capacity extended to meet the considerable post-war demand for power station equipment and rolling stock. It is at present exporting considerable quantities of heavy equipment to the Soviet Union and to China. In recent years exports have been developed to Western Europe and other parts of the western hemisphere. Brazil purchased a complete alcohol distillery which is said to be the largest in the world. A coal dressing plant was supplied to Argentina and numerous items to the Near East, Far East, and even to Australia.

The challenge of Skoda for world markets has become one of the most serious arising from Soviet bloc countries. There is little doubt that the circle and winged arrow, Skoda's famous trade mark, stands for quality and good engineering throughout the world.

Bomarc Without Bowmen

The description of America's new missile bases now being built for the Boeing Bomarc missile reads like the science fiction of ten years ago. What Boeing describe as " great electronic ghost towns " are springing up all over the United States. Their function is to defend approximately 100,000 square miles of territory and for this purpose they will be equipped with 30 to 60 ground-to-air missiles. The two bases now being built, one at Long Island, New York, and the other at New Jersey, will have 60 Bomarcs each, and a complement of less than 300 men. Twelve other bases authorised for construction in the United States will have 30 missiles each and others will be built in eastern Canada.

The firing of the missiles, which can be used to intercept targets anywhere within the 100,000 square mile area, is wholly automatic and controlled from a base which is 1,500 miles distant. The bases will consist of neat rows of air conditioned, humidity controlled concrete and steel shelters linked by underground cable to Air Force SAGE direction centres from 50 to 300 miles distant. The only continuous activity occurs in a support section adjacent to the missile area. Here are located the assembly and maintenance shops for periodic processing of the missiles and other support facilities which provide the utilities for the base.

The missile's long range assures protection to an area of considerably more than 100,000 square miles and makes it possible to locate the base away from population centres it defends. The threat which might be posed by cruise missiles and aircraft would be quickly detected by batteries of electronic devices and computers. An alert bell at the Bomarc base would sound, the shelters open automatically and the missiles, fuelled and in constant state of alert, would erect. Each missile would check itself and report its readiness to SAGE. At the push of a button it would fire—less than two minutes after the alarm sounded. After the firing, the electronic devices would continue to feed target data to the Bomarc weapons while in flight. They also would assess the effectiveness of the strike.

Popularity Policy

The search for " popularity " by large companies has become more widespread since the war and more deliberate: most will fall over backwards to have public opinion behind them. An instance of this is the decision of Caltex (UK) Limited, to withdraw their application to the Minister of Housing and Local Government for planning permission to build an oil refinery at Southampton. There had been widespread opposition to the plan, led by the Society for the Protection of the Solent Area and the Hampshire Planning Committee, and supported by many individuals. The proposed refinery was to have occupied about 1,000 acres at Warsash and had been expected to employ 450 people. The secretary of the society, Mr. F. R. Massey, expressed the views of many and their relief at the withdrawal of the scheme when he commented: " This is one of the last and most beautiful bits of coast line in southern England. It would have been a tragedy if a refinery had gone slap into the middle of it."

Caltex's attitude reflects the great caution of large American companies in their relations with the public. It has perhaps arisen from the tradition of checks and balances that successive United States Governments have defended and augmented, notably in the Anti-Trust Laws. In consequence most American firms have developed elaborate public relations programmes, some of which embrace many countries. The annual convention of the American Public Relations Associations held recently in Chicago had for its theme " Public Relations—Vanguard of Global Understanding." The winners of the Association's Certificate of Achievement, Soiltest, Incorporated, who are makers of engineering testing equipment in Chicago, have carried on " an international public relations activity to both support the People-to-People Program urged by President Eisenhower and to improve communications and sales activities between the firm and its overseas markets."

Soviet Students by Numbers

The May issue of the *LLU Translations Bulletin* published by the Department of Scientific and Industrial Research (HM Stationery Office, price 4*s*) contains a large section on information from Russia. Scientific and engineering manpower is considered under three headings—the student population in and output from higher educational establishments, employment of scientific manpower and of specialist professional manpower. These are covered in 13 tables.

Russia's students in universities in 1955-56 numbered over 166,000, and in the scientific faculties 28,000 out of 63,000 were in mathematics and physics. Students in higher educational establishments numbered 1,867,000, of whom 639,000 did correspondence courses. At October, 1955, 27 per cent of scientific workers were " technical," presumably mainly engineering, the next largest group being medical and pharmaceutical at 11 per cent. Other breakdowns are listed by nationality and specialists, but the figures are of limited use since comparative statistics are available in very few cases in the tables.

Diminishing Accident Returns

So far as can be judged from available data, the lowest national rates for accidents have been achieved by this country both before and after the last world war. The most rapid reduction in accident rates have occurred in recent years in this country and the United States. Other countries with a better than average record are Canada, the Netherlands and Belgium. The best figures are thus found among the most industrially advanced communities. Speaking on the voluntary aspects of industrial accident prevention at the recent National Industrial Safety Conference, M. Marcel Robert, chief of the occupational safety and health division of the International Labour Office, said that he linked the good performance in this country with voluntary accident prevention.

He contrasted the performance in certain Western European countries with India which is in this context a typical underdeveloped area and where the accident rates are high. It was not, he said, that such countries as India used out-of-date and possibly outstandingly dangerous equipment. Rather was it that managements were slow to instal safety devices above a statutory minimum. In other words the tradition of cheap human life is slow to be eradicated in many areas.

Academy of Management

The first members of what promises to be the most exclusive managers' club in the world have been elected by the executive committee of CIOS (International Committee for Scientific Management). The club is the International Academy of Management, created last November for the purpose of " stimulating and honouring distinguished personalities for their contributions to the field of scientific management."

Nominees for membership were submitted from the 29 countries of CIOS and only eight were elected. It is therefore a tribute to British management that one of its leading personalities should be among them. He is Mr. John Ryan, vice-chairman of the British Institute of Management, chairman of the BIM international and information and research committees and vice-chairman of the Metal Box Company. The seven other new fellows include two Americans, Mr. Peter F. Drucker and Mr. Harold P. Maynard, one Frenchman, M. Gaston Berger, one Austrian, Dr. Hugo de Haan, a Norwegian, a Dutchman and a Swiss.

The election took place at a recent meeting of the executive committee of CIOS held in Athens. One of the first activities of the Academy will be the selection of a prize paper to be read at the XIIth CIOS World Congress on Management being held in Australia from 22 February to 4 March, 1960.

Employment Follows After

There are now several signs in the economy that the recession is coming to an end. The most significant is the improvement in the steel industry—though there are some dark patches here and there, notably in coal, but also in some sections of the engineering industries. The employment figures are showing signs of following slowly after in an unspectacular fashion.

At 4 April (the latest date for which figures are available), operatives working short time numbered 116,000 which was 16,000 better than the month before. The total in civil employment also showed a modest improvement. There was a 1,000 increase from 22,797,000 to 22,798,000. The biggest advance was a seasonal jump in building and contracting amounting to 21,000. The largest drop was in engineering and related industries which showed a fall of 9,000.

The figures are not easy to interpret in the short run. For example, the food and other consumer industries have held up well over the winter and have generated a good deal of the recovery (having in fact kept it going rather longer than even the optimists dared to hope). Yet employment in the distributive trades, clothing and food was down in each of the three categories. It remains true, however, that the thaw has set in.

Exchange Posting

An imaginative idea by the Post Office has just entered upon its second phase. In January an interchange of staff was arranged between the Post Office and Unilever Limited as a means of getting an exchange of experience between the Post Office and industry. Now a second exchange on a temporary basis has been arranged. This time it is between the Post Office and Imperial Chemical Industries Limited. In this latest switch three of the four men have an engineering background or are engaged on engineering work and the fourth is a chemist. For the time being the Post Office is releasing only four people at a time. Each organisation will remain responsible for the salaries and pension provisions of its own men.

The idea is an excellent one. One of the great dangers of all managements is excessive inbreeding. This problem has already been tackled by means of seminars and working groups introduced by such organisations as the Administrative Staff College at Henley, and with considerable success. So far as the Post Office scheme is concerned most good will follow if men with good promotion prospects are exchanged and given responsible positions fairly quickly in their temporary jobs, as is the present intention.

Open to Suggestion

Suggestion schemes are a subject which stirs strong passions in reasonable men. They are part of the disputable ground in industrial relations, like joint consultation. Executives take views on them, sometimes only partly informed, and even more often prejudiced.

The Industrial Welfare Society has decided to strike while the subject is hot and hold a one-day conference on suggestion schemes on 23 June. The scale of fees and other information can be obtained from IWS Headquarters, Robert Hyde House, 48 Bryanston Square, London, W1.

The conference will start with a survey of the place of suggestion schemes in a concern's human relations policy, including comment on the success of such schemes in the US. This is followed by a resumé of organisational difficulties in setting up such a scheme and a discussion of its relationship with the method study department. There will then be two talks on first-hand experience in starting a new scheme and the conference will end with a description of current developments and an open discussion.

Flesh on the Skeleton

There are plenty of signs that the skeleton of the country's technical education programme is taking flesh. Industry continues to give help with scholarships and training. Last week two Birfield university scholarship awards were announced by Birfield Industries Limited. The statistics of technical education are looking better as well. The number of students taking sandwich courses has gone up from 1,400 in 1954-55 to over 8,000 during the current session. Even more encouraging is the increase in the number of full time teachers. According to an official of the Ministry of Education speaking recently at a Midlands conference the numbers have passed the target set by the Willis Jackson committee. But there are still some reservations about the quality, especially in the senior posts.

Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, has said recently that the Government is planning to improve the facilities for social and communal intercourse in the technical colleges so that students will get education as well as instruction in a trade or one discipline. This is of the utmost importance. It means that the skeleton will not only have some flesh on it but some personality as well.

Residual Flux

NUCLEAR and thermonuclear reactions have been treated at length in recent issues, leaving loose ends to be collected and an accumulation of current news. The following notes provide a count of the residual flux.

Distinguishing Features of Chapelcross

The major items of the Chapelcross station (AR 8 May '59) are identical with those at the Calder Hall Works of the UKAEA, but modifications based on Calder experience have been introduced where appropriate. There are, however, large differences in overall station layout. As the Chapelcross construction plan called for a four-reactor station *ab initio*, the reactors were conveniently built in line, this arrangement allowing the use of a single large turbine house with four adjacent cooling towers. Geographical compactness is thus achieved compared with the protracted A and B station layout on Calder, a factor which should ease operating and maintenance problems. As the station is about 75 miles distant from the plutonium factory at Windscale it has been thought necessary to provide a water filled storage pond for irradiated uranium to provide flexibility in operation and to ease the transport problem.

Sleeved Fuel Elements.—A recent design modification introduced on Chapelcross reactors Nos. 2, 3 and 4, concerns the introduction of removable graphite sleeves into all fuel channels to provide a solution to the stored energy problems associated with irradiation damage of the graphite moderator (AR 15 Nov. '57). The physical results of the displacements that occur appear as changes in thermal and electrical conductivity, elastic constants, thermal expansion, Hall effect, physical dimension and heat of combustion. It is the two latter properties which largely affect reactor design and operation respectively. Changes in physical dimensions are catered for by utliising the differing growth rates along the various axes, by permitting adequate growth clearance where necessary and by allowing unrestrained growth in directions not associated with ciritical alignments.

The changes in physical properties are decreased as the temperature at which bombardment is undergone is raised, presumably due to the increased mobility of the interstitial atoms with increased probability of self-annealing. This factor has eased considerably the stored energy problem at Chapelcross and Calder compared with the Windscale reactors, the respective gas inlet temperatures being 140° C and 20° C. However, no further relief can be gained from the raising of inlet temperatures in this case as the existing temperature limits on the blower casings and inlet ducts allow no appreciable advance. Accordingly, an alternative solution has been found in the provision of removable sleeves which are so designed that a small gap is left between them and the bulk of the graphite. This gap, which becomes filled with the coolant gas, acts as a thermal insulation barrier and ensures that the bulk graphite temperature is raised above its normal value, thus ensuring some measure of self-annealing. This solution has two variants in that different methods are possible for reactors which have operated and for reactors which are under construction. In the second case it is possible to modify the core bricks prior to erection and to fit removable graphite sleeves without reducing channel diameters. This solution is being adopted for Chapelcross reactors Nos. 2, 3 and 4. No. 1 reactor will use the alternative method of sleeving whereby magnox sleeves are lowered into unmodified channels, if this is necessary in the future. This latter operation reduces reactivity and channel flows thus reducing power and adds appreciably to outage times.

The Storage Pond.—The water filled storage pond for irradiated uranium is a feature not provided at Calder Hall owing to its close proximity to the Windscale ponds. The addition of the pond makes Chapelcross more akin to the new nuclear power stations now under construction for the CEGB and SSEB; these also having individual storage ponds. The pond has sufficient capacity to hold a number of cartridges equivalent to about three reactor charges. The major functions of the pond are to ensure that transport delays do not affect reactor outage times and to ease the transport problem so far as vehicles, containers and manpower are concerned.

The Chapelcross reactors like those at Calder can only be refuelled when they are shut-down and when the coolant gas pressure is at near atmospheric. It has been found that the refuelling time virtually determines the reactor outage time, any necessary maintenance can be effected simultaneously, and hence it is essential to keep refuelling time to a minimum to ensure maximum production. The storage pond assists in this by providing a storage point in the fuel cycle and then allowing refuelling operations to be almost entirely independent of external transport arrangements. The second advantage bestowed by the storage pond is that it permits utilisation of the natural radioactive decay of the irradiated fuel elements. Any decay eases the shielding problems associated with any subsequent handling operations. After the delay period it is estimated that it will be possible to transport from Chapelcross to Windscale six times as many cartridges per container as is possible from Calder to Windscale. The Chapelcross containers are about 50 per cent heavier but there is a gain factor of four in the number of cartridges per container, thus diminishing the requirement for containers, vehicles and manpower.

American and Soviet Thermonuclear Work

In a special session at the recent Convention on Thermonuclear Processes (AR 1 and 8 May '59) two lectures were given on the American and Russian controlled thermonuclear research.

United States.—The first lecture, by Dr. Van Atta, of the University of California Radiation Laboratory, was devoted mainly to outlining the basic principles of the many different approaches being followed in the United States. Only one new method has been added to the approaches which had already been reported at the Geneva Conference (see reviews in ENGINEERING, 19 Dec. '58, p. 796, and 26 Dec. '58, p. 824).

The attempts to completely stabilise the pinch effect and stop the ever present small-scale fluctuation by suitable programming of the stabilising magnetic field appear to have been unsuccessful so far. However, stability has been achieved in a new experiment at Livermore, which is essentially the inverse of the pinch effect. In a straight tube a current carrying copper rod down the centre produces a B_θ magnetic field which pushes outwards on a hollow cylindrical discharge surrounding the rod. The discharge carries an equal and opposite current to that in the copper rod, and outside the discharge there is a B_z field which keeps the plasma from the outer wall. (In the normal stabilised pinched discharge a B_θ field pushes inwards on a cylindrical discharge which has a B_z field inside.) This " Unpinch " or " Hardcore " configuration is theoretically much more stable than the normal pinched discharge. Experiments with suitably programmed fields have produced a discharge free from fluctuations. A toroidal version is now being built in which the central conductor will be a copper ring suspended electromagnetically in the toroidal tube. It will be called the " Levatron."

It has still not been conclusively verified whether the nuclear reactions occurring in the very fast magnetic mirror device Scylla at Los Alamos are truly thermonuclear. It was suggested that this might be the case at Geneva. In Scylla's favour is the fact that the plasma has been found to emit soft X-rays and this is strong evidence in favour of a high electron temperature of the order of 6 million deg. (see *Physical Review*, letters, April 1959). Dr. Van Atta was evidently one of the scientists who did not live at Los Alamos and who were not yet convinced. In addition to Scylla the experiment Triax at Berkeley also produces reactions which show no energy shift in the emitted neutrons, but the scientists involved do not think reactions are thermonuclear. (Triax is the straight hollow cylindrical discharge which is contained by a positive B_θ magnetic field pushing inwards on the outside and a negative B_θ pushing outwards on the inside.)

At Princeton, experiments using radiofrequency power at ion cyclotron frequency have shown this to be a promising method of heating the gas in the case of the Stellarator.

Soviet Union.—The Russian contribution by Dr. I. N. Golovin dealt only with the direct-current magnetic mirror method, which is one of the approaches being followed in Moscow. Two important problems were pointed out. Does the theory of magnetic mirrors apply (*a*) in the case when a particle makes a very large number of reflections as must be the case in a thermonuclear device, and (*b*) when there is a dense plasma contained by the mirrors?

A subsidiary experiment had been carried out to answer (*a*) by studying the lifetime of electrons trapped in a magnetic mirror field. To avoid trouble with injection, low pressure tritium gas was let in and the beta-decay electrons used. Provided the magnetic mirrors had no serious asymmetries, 10^6 to 10^7 reflections were recorded. This is a sufficient number to make a mirror machine thermonuclear reactor feasible.

To answer (*b*) the large mirror machine experiment Ogra has been built (see Geneva review), and it is hoped to achieve plasma densities of 10^{12} per cu. cm. A source of hydrogen molecular ions (H_2^+) has been developed giving 150 mA of 100 keV particles and the experiment has reached the stage where they are dealing with the problems associated with injecting the beam into the magnetic field. Even without heating the vacuum chamber, pressures as low as 3×10^{-8} mm Hg have been obtained using titanium pumps. The path length of ions in the mirror fields has been measured by finding the pressure at which exactly half the input ion current returns to the injector.

In private conversation the Russian scientists reported results on Alpha (their copy of Zeta) which were similar to those obtained on Zeta and Sceptre. The enhancement of the axia magnetic field has been shown to be due to the anisotropy of the electrical conductivity and not the compression of the plasma. Calculations had been made on the radiation due to impurities but so far there were no experimental results to resolve the electron energy loss problem.

Both the Russian and American scientists have checked their measurements of the cross section for the break up of deuterium molecular ions by neutral molecules. This cross section is very important for both Ogra and DCX. There is still the same discrepancy of a factor of about 2·5 in their respective values as at the Geneva Conference. It was suggested that a neutral country such as Switzerland should repeat the measurement!

Heating and Containment

To produce a useful number of thermonuclear reactions it will be necessary to achieve high temperatures (10^7 to 10^9 °K) and to keep the hot material away from material walls, probably by means of a magnetic field. The containment time (by a magnetic field) is limited by collisions in the gas; because the collision rate decreases as the temperature increases, long-time containment is likely to be easier at the highest temperatures, so it would seem reasonable to consider the heating problem first. (Paper by R. A. Fitch.) In the last few years considerable effort has been directed to the pinch effect as a means of heating and confining a plasma. In the pinch process, hot plasma is confined by the self-magnetic forces of the currents flowing in the plasma, and energy is put into the gas by a number of different processes: by joule heating, by compression, and by various types of instability mechanism. (Paper 2882, Rapid Compression of a Plasma with Azimuthal Currents, G. B. F. Niblett.)

In the case of heating by compression, a rapidly rising magnetic field can sweep up an ionised gas so that the field behaves as a piston and does work on the gas according to the well-known relation $W = \int P\,dv$. (Rapid Heating for Controlled Fusion Research, R. A. Fitch, IEE Convention on Thermonuclear Processes.)

Fast and Slow Pinches

The energy input by joule heating, J^2/σ per unit time, is small at high temperatures because of the increase of plasma conductivity with temperature. The energy input by compression derives from the work done by the magnetic force, $J \times H$, where H is the self-magnetic field of a current element J. In a slow pinch process the magnetic forces are in equilibrium with the kinetic pressure of the gas at

each stage of the compression and hence the gas is heated adiabatically or reversibly, whereas in the fast pinch the aim is to generate the magnetic forces so rapidly that work is done irreversibly on the plasma. This rapid process is likely to have a number of advantages over joule heating; in particular, the energy input is not limited by the conductivity of the plasma, and the energy is transferred initially to the ions rather than, as in joule heating, to the electrons. (Paper 2882.)

Axial Field Containment

In the most common form of pinch the current is axial (in the z-direction), the confining field is azimuthal (in the θ-direction), and the confining force on the plasma is produced by a term, $J_z \times H_\theta$. Alternatively, a plasma may be compressed by azimuthal currents and an externally associated axial magnetic field; the confining force, $J_\theta \times H_z$, is again directed radially inwards. In addition, of course, to these extremes, the plasma current and confining field may have components in both the axial and azimthal directions. The arrangement of devices employing this system used for preliminary experiments at AWRE is shown in Fig. 1. (Paper 2882.)

Shock Variation on the Pinch System

It has been shown that a plasma can be heated and confined by a rapidly rising axial field produced by azimuthal currents, with the rapid increase in field strength providing shock heating. An experimental programme has been planned at AWRE to test these basic concepts. An essential requirement for rapid heating with rising axial fields is a low-inductance energy source, and experiments have begun with the condenser bank Maggi designed to have a very low inductance. Preliminary work has demonstrated the importance of producing a conducting gas before application of the main discharge and attention is being directed to this problem. One advantage of the pinch process using azimuthal currents is likely to be its freedom from the catastrophic instabilities associated with axial currents, and it is planned to verify this stability in a straight tube. Finally, experiments are being designed to study the system in a torus and to inhibit the drift to the outside wall by means of an applied rotational transform. It is found that after the initial rapid heating process, the plasma and magnetic field diffuse into each other and the configuration is similar to that in the Stellarator, with similar stability problems and similar possibilities of continuous operation. (Paper 2882.)

Supply for Heating by Compression

It has been shown that in systems employing compression heating the compression should be very rapid. The field should build up quickly and it is therefore necessary to provide the highest possible initial dI/dt in the circuit producing the field. In addition, currents of about 10^7 amperes are required. At the present stage, a rapid-discharge capacitor bank appears to offer the best means of meeting these requirements. Rapid discharge implies low bank inductance, L_B; it is shown that the bank inductance, when minimised, is proportional to the bank voltage, V_B. Using this result it is found that the requirements of high initial rate of change of current, I_i, and high peak current, I_p, make conflicting demands on the bank design. High I_i demands large L_B and V_B; High I_p demands low L_B and V_B. The value of L_B is to be compared with the inductance of the circuit generating the compression field, L_F. Fortunately, L_F increases as the compression proceeds, going from L_{F1} to L_{F2}. High I is required initially, high $\dot{I}$ ultimately: so it is suggested that the bank inductance should be chosen within the interval $L_{F1} < L_B < L_{F2}$. After the heating phase it is necessary to maintain the field—and hence the current—for as long as the hot gas can be contained.

The capacitor banks require to be designed to have minimum inductance. If the essential elements of the bank—condensers, leads, switches—are paralleled, their inductance contribution can be made arbitrarily small and the bank inductance reduces approximately to that of the collector which connects the leads to the field circuit. The collector inductance is analysed and it is concluded that the minimum bank inductance, and hence the maximum I, is limited by the electric strength of the best available insulating material. With currently available materials the maximum attainable I is about 3×10^{14} A per sec. (Rapid Heating for Controlled Fusion Research, R. A. Fitch.)

Million Ampere Generator: Maggi

The largest capacitor bank at AWRE using the parallel spark-gaps system, known as Maggi (million-ampere generator), has an energy of 45 kJ; the essential features of the design are shown in Fig. 2. The bank comprises 200 capacitors, each of 0·5 μF capacitance and rated at 30 kV for rapid oscillatory discharge; each is switched by a simple 2-electrode direct over-volted gap mounted on the capacitor terminal, and connection to the collector is by 50-ohm coaxial cables (Z_3) which are 5 ft long, giving a characteristic time of 15 millimicrosec. Each spark-gap comprises two copper electrodes—a plain one connected to the condenser and a hollow one connected to the main cable. An annular irradiating gap is formed in the hollow electrode by means of a central irradiating pin. The trigger-pulse cable (Z_2) is connected to the irradiating pin, and the trigger pulse, in feeding into the main cable, sparks across the irradiating gap: it is found that the statistical time-lag in sparking is thereby reduced to a negligible value (less than 2 millimicrosec). The trigger-pulse generator in Maggi consists of a single pressurised spark-gap (" master-gap ") which discharges the 200 trigger-discharge cables ($Z_1 = 50$ ohms) into the 200 trigger-pulse cables ($Z_2 = 50$ ohms). The gap is pressurised to 350 lb per sq. in to reduce its length and hence its inductance. The trigger-discharge cables are pulse charged from a Marx generator in approximately 0·7 microsec: the master gap is untriggered and is set to break down on the rise of the charging pulse, at approximately 60 kV. The mean rate of rise of the output trigger pulse is approximately 1·3 kV per millimicrosec over the first 10 millimicrosec. The Marx generator is triggered from a thyratron circuit, which incorporates a variable delay so that the bank can be fired at any instant relative to an independent event with a jitter of less than $\pm$ 0·2 microsec. The main capacitors are charged to a predetermined voltage from a common supply in approximately 5 sec, with feedback circuits to prevent drift after the charging transient; they are connected to the power supply by individual resistors, which isolate them under fault conditions, and the resistance is sufficiently high to prevent the bank maintaining the spark in a gap which happens to break down spontaneously. Details of Maggi appear in the table below. (Low-Induction Switching Using Parallel Spark-Gaps, R. A. Fitch and N. R. McCormick.)

TABLE—*Characteristics of Maggi*

Capacitance C_B	99·8 μF
Voltage V_B	30 kV (max.)
Energy, W_B	45 kJ
Inductance, L_B	5·3 mμH
Resistance, R_B	2 milliohms
V_B/L_C	5·6 kA per millimicrosec
Peak current on short-circuit at $V_B = 25$ kV	3,360 kA
Quarter period on short-circuit	1·25 microsec
Number of spark-gaps, n	200
Characteristic time	15 millimicrosec
Breakdown voltage of master gap	60 kV
Slope of trigger pulse	1·3 kV per millimicrosec

Stainless Steel Liner for Zeta

The problem of devising a stainless steel liner of sufficient resistance to be suitable for use in the Zeta torus (see Atomic Review 8 May '59) was tackled jointly by AERE and the Bellows Division of Teddington Aircraft Controls Limited at Ammanford. The solution adopted was to corrugate the stainless steel tube in 36 separate sections of wall thickness 0·017 in using 2½ convolutions per inch each being 0·7 in deep. This operation used forming and welding techniques developed at Ammanford for the construction of bellows pipe expansion joints. These convoluted tubes were then welded together to form 12 sections, to the ends of which were fitted stainless steel joint rings enabling the liner system to be installed in Zeta in 12 separate sections forming a vacuum-tight liner which could be bolted together from inside the torus. The toroidal liner system has a 38 in bore and a main toroidal path length of only 36 ft, but produces a resistance of 0·02 ohms. The inside of the completed liner had to be chemically clean, and a heavy oxide coating was required on the outside to provide a high degree of heat radiation to the water-cooled torus body. The liner, which was illustrated on page 607 (8 May), has operated successfully over a considerable period.

UK and US Exchange Fissile Materials

Under the recent agreement between the United Kingdom and the United States, Britain will supply plutonium in exchange for US uranium 235.

Chair of Nuclear Engineering

Mr. W. B. Hall, deputy chief scientific officer in the Sellafield Laboratories of the UKAEA has been appointed to the chair of nuclear engineering in the department of engineering, Manchester University.

Health Physics Symposium

Professor Niels Bohr, chairman of the Danish Atomic Energy Commission, was président d'honneur of the Symposium on Technical Methods of Health Physics which was jointly organised by the OEEC European Nuclear Energy Agency and the Danish Atomic Energy Centre at Risø, near Copenhagen, from 25 to 28 May. The purpose of the symposium was to bring together experts from West European countries, the United States and Canada to discuss scientific and technical aspects of health protection in nuclear installations.

GEC—MAN Agreement

Initially for a term of 10 years, an agreement signed between the British General Electric Company and Maschinenfabrik Augsburg-Nürnberg AG (MAN) grants the German company exclusive licences in the Federal Republic to GEC nuclear patents. Any MAN inventions concerning nuclear plant will likewise be available to GEC. MAN will pay a capital sum and a service fee for each kilowatt of guaranteed electrical output from nuclear power stations ordered from them. The GEC small-scale reactor (AR 15 May '59) is expected to be of special interest.

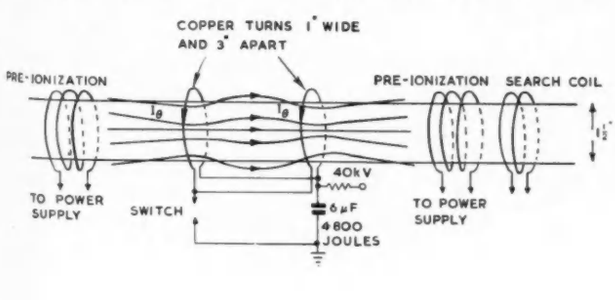


Fig. 1 (left) Arrangement of fast pinch device.
Total inductance ≃ 60 mμH.
Inductance of soils ≃ 20 mμH.
Rise time ≃ 1 microsec.
Peak current ≃ 400,000 amperes.
Initial $dI/dt \simeq 6 \times 10^{11}$ amperes per sec.
Initial dH/dt at wall ≃ 10^{19} gauss per sec.
Initial $E\theta$ at wall ≃ 2,500 volts per cm.

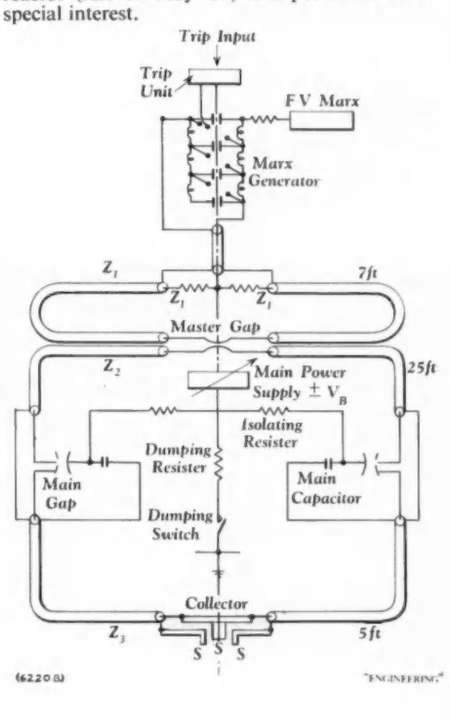


Fig. 2 (right) Features of the Maggi capacity bank.

SPRINKLING WATER AND FOOD ON LAND AND CROPS

ENGINEERING flourishes in many fields, not least in those of the farmer. There, and in general, the techniques taking deepest root are those with ability to grow, able to evolve as agriculture itself evolves, influencing the evolution of agriculture itself. The internal combustion engine is one example. A newer one is mechanised irrigation, for which some interesting new equipment was demonstrated recently by Wright Rain Limited.

Basically, irrigation is an age-old idea; but present-day equipment has potentialities that extend far beyond those of the ditch and watering can. New methods of farming become practicable. The farmer is given a fluid distribution system: he can use it not only for watering but also for applying chemical fertilisers and liquid manure, or for frost protection of his crops. By using irrigation piping to transport manure from the cattle yard to the pasture, the farmer can improve the efficiency of "zero grazing" methods. (This is a system whereby grass is always cut in a pasture and brought in to the cattle, rather than putting them out to graze.) He might even bed his cattle on foam plastics materials and dispense with straw, growing corn on short stems, saving labour by doing so. The philosophy behind this line of argument is that land, livestock, and labour must be used more efficiently; the large amount of materials handling that at present takes place on the farm needs to be reduced.

Fig. 1 By pumping farmyard manure through irrigation piping, labour costs are reduced and an even application obtained.

SPRINKLER IRRIGATION

Irrigation in Britain has never been a pressing need. But weather records show that the mean summer rainfall in south-eastern England is about 5 in short of what the crops could use. In that part of England irrigation is needed 8 or more years out of 10, while for the rest it is needed 5 or more years out of ten—generally in June, July, and August. Probably the most important crop benefitting from irrigation in Britain is grass. Grain crops show a varied response; most other vegetables and fruit are improved by irrigation.

One of the arts of irrigation is to see that drainage through the subsoil does not occur. At "field capacity" water surrounds each soil particle, most being held in wedges between particles. From the wedges plants get most of their water. Soil texture influences field capacity and also the rate of infiltration of water. The latter quantity has important economic implications: the faster the soil absorbs water the cheaper the capital cost of the irrigation equipment. But damage can occur to soils if water is applied in too large a drop size—to a severe extent if drop size reaches 4 mm.

To irrigate any land an abundant supply of water is essential. The average farm pond does not give anything like sufficient water, and the public water supply costs too much. The farmer finds suitable irrigation sources in rivers, small streams used in conjunction with reservoirs, lakes and ponds fed by springs, and boreholes. If the area to be sprinkled lies alongside the source and the pumping unit is a mobile one—such as might be driven from a tractor—there is no call for a water main to the distribution equipment. Where a permanent main is needed it may be of cast iron, galvanised iron, steel, or asbestos piping. A portable main usually consists of aluminium alloy piping connected by some form of quick coupler.

Early sprinkler equipment used in Britain consisted of galvanised iron piping, between 1 and 1·5 in in diameter, drilled with small holes at 2 ft centres. When it was found that the holes corroded, they were replaced by small brass jets. At first the line was rotated through 180° by hand; later, water-driven oscillators were added, giving what is now known as an oscillating spray line. Such equipment can operate in lengths of up to 150 yards and apply water at a very slow rate (1 in in 6 to 8 hours). However, it needs water at a pressure of 40 to 60 lb per sq. in, and labour costs are high.

A large hydraulic sprinkler was then made. It operated at a pressure of 100 lb per sq. in and discharged upwards of 160 gallons per minute over a circle of an acre. However, only with crops such as sugar cane, where it is almost impossible to move smaller sprinklers owing to the height of the crop, is it an economic proposition. It has excessive power costs, requires large piping, and produces a large droplet size. In addition, the distribution is unduly disturbed by wind.

At present, probably 90 per cent of the overhead-irrigated land in the world is fed by sprinklers that follow a standard pattern. They operate at peak efficiency for a pressure of about 35 lb per sq. in, and have two nozzles: a long-range high-capacity nozzle to cover the outer part of a circle of at least 90 ft diameter, and a shorter range nozzle to cover the inner part of the circle. Rotation of the sprinkler is brought about by a mechanical device operating on the principle of a hammer, which is raised by the stream of water from one of the nozzles and returned with force by a spring or counterweight (Fig. 3). The device proved to be cheaper and more dependable than a turbine or reaction rotating device. Water is distributed in a conical pattern, with heaviest application at the centre, reducing to a feather edge at the periphery. This pattern has been found by field experience to be the best. Sprinklers are rated by their capacity in gallons per minute with varying pressures, and by their rate of application in inches per hour with different spacings.

Field experience has also produced a near standard pattern for sprinkler spacing. They are placed in a line 35 to 40 ft apart and this "lateral line," as it is called, is usually moved consecutive intervals of 60 ft. In this way the maximum lateral move is obtained, while a good coverage through the lateral length is assured. The rate of application may vary from 0·2 to 0·75 in per hour with the same sprinkler, and is determined by selecting the appropriate combination of nozzles.

Fig. 2 The manure pump is an open-vane impeller type with a quick-release inspection plate to allow clearance of blockages.

MANURE RAIN

Having installed a distribution system for irrigation, the farmer can adapt it to carry manure from cattle or pig sheds to fields. In this way the whole irrigation equipment need not lie idle during wet months. Also the labour cost involved in carting straw and dung can be reduced.

Full use of farm yard manure has never been made in Britain, principally through loss of the liquid content at byre or piggery and through loss of ammonia in the heaps. While the diet and breed of animal will cause variations in the amount of solid and liquid manure produced in a year, it has been estimated that cattle produce about 15 tons per head and a fattening pig 35 cwt. At current market prices, this represents an annual fertiliser value of about £14 and £1 10s. Nearly half the nutrient value is in the liquid part of the manure.

It is not possible to use the same pump and sprays for manure as are used in a standard irrigation system. The solids would cause blockage. A system introduced last year by Wright Rain Limited, Ringwood, Hampshire, replaced the usual centrifugal irrigation pump by a three-cylinder piston pump, which was intended for operation with a "mixer cutter." Straw and solid dung were forked into this latter device, which contained a constant level of liquid manure, fed from a separate storage tank connected to the farmyard drain. The mixer cutter required a 5 h.p. drive and ensured that the straw was cut up in small enough lengths for the piston pump to handle. At the discharge point in the system a hand directed sprinkler or automatic sectoring sprinkler was used.

The system was, however, expensive, largely because of the high cost of the piston pump.

This year the company have introduced a simpler and cheaper version of the "Manure Rain" system, as it is called (Figs. 1 and 2). An open-vane centrifugal pump (type MR3) has replaced the piston pump (the prices of the two are about £80 and £400 respectively), and as mechanically-operated sprinklers tended to be blocked by stones and a man had to be at the discharge end anyway to move the sprinkler's position from time to time, a hand directed sprinkler has been made the standard fitting. The mixer cutter has been removed and long straw can no longer be handled.

The open-vaned impeller of the pump, shown in Fig. 2, is capable of passing solids of up to ¼ in diameter and an occasional piece of long straw. Because of its construction to meet this requirement, the pump operates at an efficiency below 50 per cent. But as it is used for, perhaps, only one hour a week, the efficiency hardly affects the running costs It does, however, prevent the pump being an economical proposition for irrigation work and means that it cannot lift manure to heights much over 50 ft; heights of 100 ft and more require the use of the piston pump

Because of its light duty and the requirement of low cost, the centrifugal pump is of simple construction and largely made of a cast iron. Two versions are available—a bare-shaft unit suitable for driving by an electric motor or diesel engine, and a unit for tractor drives, incorporating a 1 : 3·1 gearbox. The latter, shown in Fig. 2, has a conventional two-wheel trolley and universal shaft for power take-off drive.

The pump has a 3 in suction and 3 in delivery. It can be primed with a Wright Rain priming pump and can be fitted with a standard aluminium suction pipe arrangement. A gate valve must be fitted to the delivery branch, as the company's combined delivery and non-return valves—developed for irrigation purposes—are not suitable for use with manure. The pump casing incorporates a quick-release inspection plate to give easy access to the impeller to clear blockages.

In the absence of the mixer-cutter, the mixture is pumped straight from the concrete storage tank. This is generally underground and liquids from the yard drain into it. Agitator paddles are fitted in the tank, revolving at about 15 r.p.m. and requiring about 1 h.p. for each 6 ft length of paddle shaft.

To start with, water is run into the tank to a depth of about 2 ft. As dung collects in the yard it can be washed down by using the manure pump to pump water from the tank. Even as the solid content builds up the procedure is continued, the solids being allowed to settle before pumping starts. Before application to the fields, the mixture in the tank is well stirred, to give a good consistency.

The Manure Rain system is particularly suitable for use with zero-grazing methods. One advantage of this method of feeding is that the cattle consume all of the grass fed to them, whereas in the fields they tend to browse where the flavour appeals to them. A problem produced by the method is the large accumulation of manure in the cattle yard. With the Manure Rain system it is possible to return this to the fields with little labour. And the spraying method appears to make the grass more palatable, for when cattle are left to dung a field, it is some time before they will graze on the patches they have treated; this is not the case with grass grown under Manure Rain.

The present system, although much cheaper than the system using the piston pump and mixer-cutter, requires that the straw be treated in the traditional manner. There is, however, a school of thought that deprecates the use of labour to bring straw in from the fields and to take it out again, and looks to the use of some other bedding material for livestock. Foamed plastics mattresses have, in fact, been suggested for the work.

TOWING PIPELINE

A feature of the conventional sprinkler system of irrigation is the necessity of moving the lateral lines of sprinklers. The original way of doing this was to uncouple the individual sections of pipe, load them on to a trailer, tow the trailer to the new lateral position, unload and recouple. As pipelines for this work reach lengths of 600 ft or more, the labour involved was appreciable and the equipment was out of action for some time.

Wright Rain Limited have now introduced the "Tow Line" system, which is intended to overcome these objections and is suitable for large fields of pasture. It uses aluminium skid pans attached to each coupling on a 4 in lateral line, as shown in Figs. 3 and 4. The line can then be towed complete by a tractor or similar vehicle. When the line is being moved across a field, the manoeuvre employed is that shown in Fig. 5. To provide some flexibility a short length of rubber hose is inserted into the pipeline, as shown in the lower diagram. One man with a tractor can move the adapted line in about a third of the time required by the hand-loading method.

Consideration was given to this type of system by the company two years ago, but they decided that farm labour was not expensive enough to justify development of such a technique. Later the requirement for the system came from New Zealand, where farm labour is scarcer. Now as labour in Britain becomes less plentiful, the system may be a practical proposition for large acreages of pasture.

GARDEN SPRINKLER

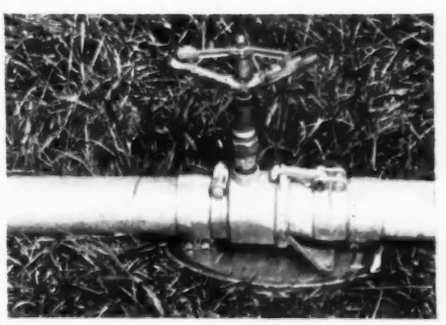
A new lightweight low-capacity sprinkler has also been introduced by Wright Rain. It weighs only 2 oz and has a sealed bearing using ptfe and rubber washers. The standard model has one plain and one slotted nozzle and is suitable for garden or nursery use. By twisting the nozzle tube, the height of the water trajectory can be lowered from the standard 5 ft to about 12 in. Operation is possible at pressures as low as 5 lb per sq. in, but for good water distribution a pressure between 20 and 30 lb per sq. in is recommended. A spacing between sprinklers of 20 ft by 20 ft is used.

DEFROSTING CROPS

Frost protection of crops can be achieved with irrigation equipment, and automatic control gear has now been introduced by Wright Rain Limited. A contact thermometer and control box are provided. These can either set off an alarm bell or start an irrigation pump, as soon as the temperature falls to 32° F.

Protection of fruit trees and bushes is obtained by continuously sprinkling the crop with water throughout the whole period of frost. As the water freezes it releases its latent heat and keeps the temperature of the plant high enough to prevent damage by frost. Work at East Malling Research station has shown that during radiation frosts—that is, on a still night—a precipitation rate of 0·07 in per hour will give protection against a minimum screen temperature of 26° F, while at a rate of 0·24 in per hour will give protection against a temperature of 21·5° F. Spring frosts in Britain rarely fall as low as this and a precipitation rate of 0·10 to 0·12 in per hour gives ample protection. (This represents 2,300 to 2,900 gallons per acre per hour.) With relatively small areas of a few acres only, it is possible to modify existing portable sprinkler lines. Where larger areas are involved, particularly in orchards and soft fruit plantations, a permanent arrangement using underground Polythene pipe may be more suitable.

Fig. 3 The fitting of skid pans under each pipe joint makes it possible to tow complete lengths of piping across pastures. A standard type of sprinkler, relying on a hammer action for rotation, is shown.



Cox's and James Grieve apple trees were sprinkled at a rate of 0·1 in per hour during 7° F of frost at East Malling research station in May, 1957. In August of that year the trees that had been sprinkled bore a full crop, whereas adjoining unsprinkled trees had no fruit at all.

Wright Rain Limited have been making a centrifugal pump for irrigation for some time; it is available with or without a gearbox. To meet the demand for a compact diesel-powered pump, the company are developing a range of close-coupled pumps. They will be single-stage centrifugal types in 1·5, 3, 4 and 5 in sizes, the first two being powered by Ruston air-cooled diesels and the larger sizes by Fordson 4 and 6 cylinder diesels. The smallest unit, using a 6 h.p. power pack running at 1,800 r.p.m., develops heads of 140, 120, and 115 ft for discharge rates of 70, 80, and 100 gallons per min. The range will be on the market next year.

Equipment like that described is making a significant difference to agricultural and horticultural methods. It is engineered intelligently and imaginatively, with a down-to-earth sense of realities on the land.

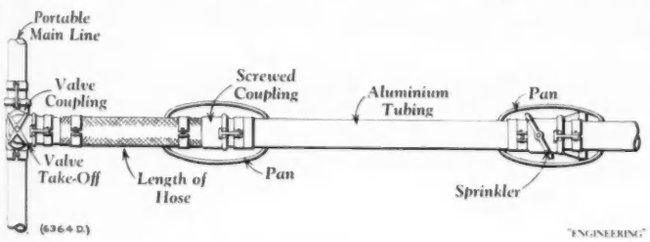


Fig. 4 The complete installation of the "Tow Line" system requires the introduction of a short length of rubber hose to provide flexibility.

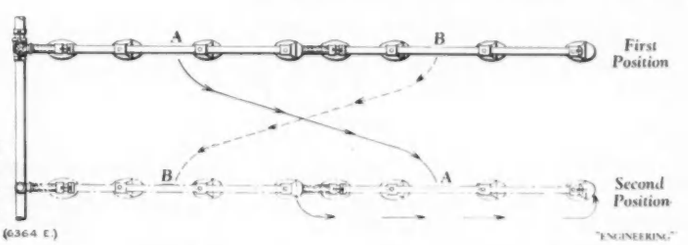


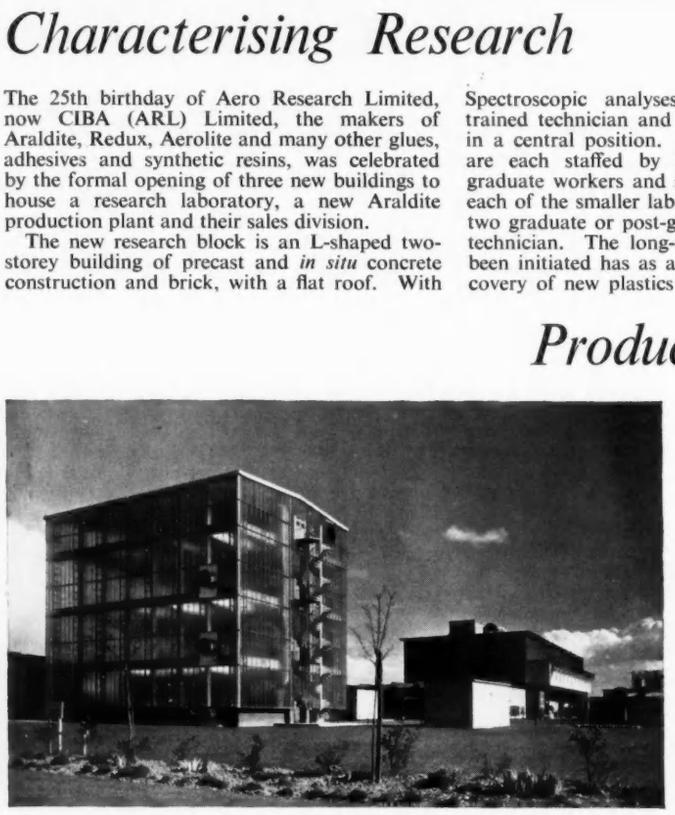
Fig. 5 To move a lateral line to its new position, the line is broken in the centre and towed diagonally in two portions. (6364 E.)

THREE NEW BUILDINGS

Characterising Research

The 25th birthday of Aero Research Limited, now CIBA (ARL) Limited, the makers of Araldite, Redux, Aerolite and many other glues, adhesives and synthetic resins, was celebrated by the formal opening of three new buildings to house a research laboratory, a new Araldite production plant and their sales division.

The new research block is an L-shaped two-storey building of precast and *in situ* concrete construction and brick, with a flat roof. With an earlier research block, it encloses three sides of a quadrant laid out with lawn and flagged paths. The walls consist mainly of large panels of polished plate glass. Internally there is lavish use of teak, in conjunction with exposed facing bricks and white paint. In the corridors, the artificial lighting is diffused by means of Aeroweb honeycomb panels.



Heating is by hot-water radiant panels in the ceilings. A system of ducting is built throughout the block to provide fresh air and for extraction from fume cupboards. All the laboratory benches are of teak glued with Aerodux 185 adhesive and cupboard doors have laminated plastic facings. Araldite 820 RH has been used as a surface coating in the fume cupboards and in other places where a highly corrosion-resistant finish was called for.

The total floor space is 12,800 sq. ft, the ground floor being devoted to long-term research and the upper floor to the investigation of current applications of the company's products. The ground floor has two double laboratories furnished with peninsular benches, so arranged to leave space at one end of the room for free-standing apparatus. In addition three single laboratories are fitted with island benches. Spectroscopic analyses are conducted by a trained technician and the apparatus is housed in a central position. The double laboratories are each staffed by four graduate or post-graduate workers and several technicians, while each of the smaller laboratories is supervised by two graduate or post-graduate workers and one technician. The long-term research which has been initiated has as a general purpose the discovery of new plastics materials with improved structural strength, high temperature stability and electrical properties. The scope of the work is not restricted to adhesives, but embraces the use of plastics in many fields.

The laboratories investigating current problems also handle methods to meet customers' special requirements. A big programme of research is necessitated by the rapid growth of the chipboard industry. A large tonnage of urea-formaldehyde resins sold by CIBA (ARL) in the United Kingdom is used for this purpose. In the field of epoxy resins, work is in progress to formulate new hardeners. The bonding of stainless steel and adhesives for printed circuits are two other lines of research at present being pursued.

Miscellaneous problems dealt with from time to time include some related to Redux metal-to-metal bonding, to Aeroweb aluminium honeycomb manufacture, and experimental work in connection with patents.

Araldite epoxy resins were introduced by the parent company, CIBA Limited, of Basle, during the war; the first resins of this type to be manufactured in the United Kingdom were made at Duxford in June, 1950, and the plant then installed, with modifications and additions, has met a steadily growing demand. It was soon realised that demand would outstrip the capacity available, and planning for a much bigger production unit was put in hand in May, 1955.

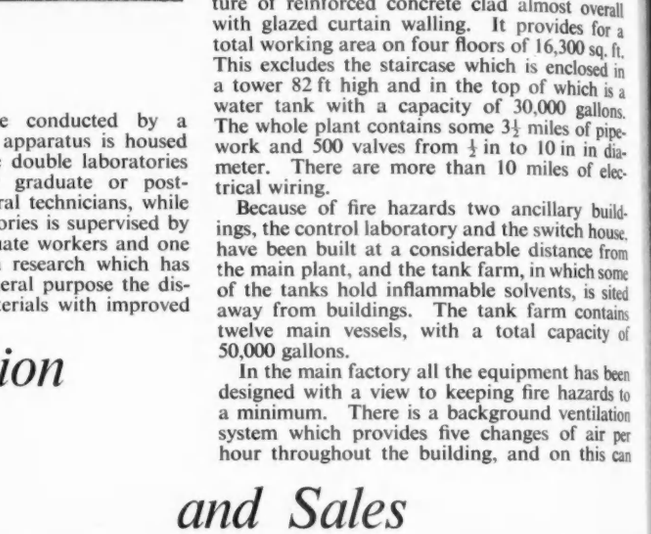
The new plant, now in production, has a capacity five times that of its predecessor. It is maintained by three men per shift, and its output rate per man-hour is three times that of the old plant. The buildings have sufficient accommodation, and services have been installed, to enable the current capacity to be doubled.

The main building is an elegant modern structure of reinforced concrete clad almost overall with glazed curtain walling. It provides for a total working area on four floors of 16,300 sq. ft. This excludes the staircase which is enclosed in a tower 82 ft high and in the top of which is a water tank with a capacity of 30,000 gallons. The whole plant contains some 3½ miles of pipework and 500 valves from ½ in to 10 in in diameter. There are more than 10 miles of electrical wiring.

Because of fire hazards two ancillary buildings, the control laboratory and the switch house, have been built at a considerable distance from the main plant, and the tank farm, in which some of the tanks hold inflammable solvents, is sited away from buildings. The tank farm contains twelve main vessels, with a total capacity of 50,000 gallons.

In the main factory all the equipment has been designed with a view to keeping fire hazards to a minimum. There is a background ventilation system which provides five changes of air per hour throughout the building, and on this can be imposed additional ventilation so that the air is changed 30 times per hour. All floors are dished to contain spillages.

Production and Sales



Araldite resins are made by reacting two chemicals—epichlorhydrin and diphenylolpropane. This is done under controlled conditions to give products with varying properties according to the way they are to be used. After the initial reaction of the raw materials, there are washing and filtering processes to ensure purity in the final product. Some of the processes call for the use of highly inflammable solvents, and it is these which constitute the main fire risk.

On the east side of the building is a brick-built store with a floorspace of 4,700 sq. ft and an average height of 23 ft. It is a feature of this store that the roof is supported by four lattice timber trusses of 72 ft span made by Rainham Timber Engineering Company Limited using Aerodux 185 adhesive. The floor is also dished

to contain spillages. All doors are protected internally against fire.

The existing sales buildings have been extended by the addition of two wings, thus enclosing a courtyard, and more than three times the amount of floorspace is now available for the sales and publicity divisions. The new wing facing the road is timber-built of two storeys with a flat roof, the upper floor being supported on attractively designed portal frames, laminated with Aerodux 185 resorcinol resin glue. The single stanchion of these frames is branched to form a main beam inside the building and a short cantilever section outside. Built by Saunders-Roe (Anglesey) Limited, the frames are entirely exposed and thus form a major feature of the building and of the new display room. This room, 70 ft by 20 ft, is paved with Blue Hawk tiles made by British Plaster Board Limited. This type of tile was developed by CIBA (ARL), and was manufactured for some years at Duxford. There is underfloor heating by means of circulating hot water.

The new building has a floor space of 15,000 sq. ft. In addition to the display room, there are two large laboratories and 38 offices, of which 33 are contained in the three-storey brick-built wing. This has a low-pitch roof using Aerolite glued timber beams of the Cawood Wharton system, supporting Stramit roof panels, which are in turn covered with woven glass-silk and bitumen.

Several offices in the new wings have hardwood veneers glued to ordinary 1 in floorboards by Aerolite adhesive. The veneers are sealed with various protective resin coatings, also made by the company, and polished. A sales conference room adjoining these offices has two walls pannelled with Columbian pine. The courtyard in the centre of the block is crossed by flagged paths and ornamented by a fishpond.

The consulting engineers and architects for the research block and the Araldite production plant were Ove Arup and Partners, London, W1, and the contractors William Sindall Limited, Cambridge. For the sales block, the architects were Westwood Sons and Partners, London, SW1, and it was built by F. J. and T. E. Prime of Cambridge. Heating and ventilating throughout the new buildings has been installed by G. N. Haden and Sons Limited of London, and the electrical contract was let to Rashleigh Phipps and Company Limited. The new work, including an engineering services building that is still under construction and together with the services, gardens, carparks, have cost £½ million.

FOREIGN EXCHANGE FOR KOYNA PROJECT

The International Bank has granted a loan of $25 million to the Indian Government to meet foreign exchange costs of the Koyna hydro-electric project in Bombay State. The project is being tackled in three stages. In stage 1 (for which the loan has been made) a dam is being built across the Koyna river and four 60 MW generating sets installed; transmission lines are also being built. Stage 2 will double the capacity with the installation of four more 60 MW sets. Stage 3 will add another 90 MW to make the total capacity 570 MW. Most of the work is being undertaken by Indian contractors.

SIXTY YEARS OF A GERMAN CONTRACTOR

On 10 May, 1898, Edward Züblin, a mechanical engineer, founded the building enterprise now known as Ed. Züblin AG of Stuttgart. To celebrate their 60th birthday the firm arranged for publication of a history of the firm as a contribution to the history of reinforced concrete.

The volume is available in an English edition, illustrated by pen sketches of men who have contributed much to the company, colour photographs of fine buildings, and an appendix of some 80 black and white pictures of work by the firm both in and out of Germany.

Amalgamation and Education of Civil Engineers

In the course of his reply to the toast of "The Institution," Professor A. J. Sutton Pippard, President of the Institution of Civil Engineers, at their annual dinner last week, suggested that, in spite of the growth in education facilities generally, the number of first class intellects had not increased; nevertheless the engineering profession had got to ensure that it continued to receive its fair quota of ability. The basic qualification of the "general practitioner" among young engineers today was a first degree, and it was to assist maintain this position that the Civil Engineering Scholarships had been founded so that young men, who might be barred from receiving state aid towards university education because of parents' income, could enjoy a full-time engineering degree course.

To encourage advanced—even specialist—training, and yet leave time within a first degree for a wide education, including liberal studies, the Institution would accept attendance at a one year post-graduate course as part of the practical training required before corporate membership was attained.

Professor Pippard also referred to discussions that had been begun with the object of uniting the Institution and kindred societies. He mentioned particularly the Institution of Municipal Engineers and said that some proposals were soon to be put before the councils of the two institutions. He was at pains to emphasise the amalgamation with other societies should not, and would not be allowed to be, inconsistent with present standing of the Institution. He also reported that during the last year the research committee of the Institution has been reformed and had begun work.

Power Developments in Victoria, Australia

Power generated by the Victoria State Electricity Commission is increasing by about 7 per cent per annum, and output is now just over 5,100 million kW-hr a year. Installed capacity (at 30 June, 1958) is 1,211 MW. Yallourn power station in the Latrobe Valley generates 44 per cent of the total, and 65 per cent of the output is based on the brown coal deposits in the Valley. Hydroelectric sources account for 11 per cent of the electricity generated.

Extensions at Yallourn will bring the installed capacity there to 621 MW by 1962, and at nearby Morwell the commission is developing a second brown-coal power and fuel project. By 1961 the installed capacity will be 91 MW and brickette output 1,500,000 tons annually. At Hazelwood, a 1,200 MW station is expected to be in operation by 1964. Further developments are also planned for the Kiewa hydropower project and current is also to be bought from the Snowy Mountains Authority.

Modular Coordination in Building

The Canadian Standards Association have prepared a Code—Specification A31-1959, *Modular Coordination in Building*—as a guide for manufacturers of building components when establishing sizes for their products. The first edition defines the terms and outlines the application of the modular system. It covers the method of applying the system to determine the dimensions of coordinated building components, prepare construction working drawings, and effect economies in manufacturing and on-site work.

Promoting Timber Construction

The 25th annual general meeting of the Timber Development Association was held in London on Wednesday, 27 May. Copies of the annual report are available at 5*s* (post free) from the Association.

During the last year nearly 25,000 inquiries concerning the use of timber were handled and design assistance was given to nearly 9,000 applicants; special designs were also prepared for 133 projects. Research projects in hand numbered 43 and 60 courses were sponsored which were attended by 1,657 students.

The Ministry of Housing and Local Government have recently pointed out that, as a consequence of the afforestation, increasing supplies of home-grown timber are coming on to the market. The Ministry have asked local authorities to do all they reasonably can to encourage the use of such timber.

Bursary in Timber Engineering

The Timber Development Association are to award a bursary in timber engineering, tenable at any British university from October, 1959. Candidates must hold a degree in engineering or mechanical sciences and have a good knowledge of the theory of structures. The holder will receive £350 per annum, in the first instance for one year, but the bursary may be renewed for a second year; the work undertaken should lead to a higher degree.

Application forms are obtainable from the Director, TDA, 21 College Hill, London, EC4.

Wind Effects on Roofs

The effects of wind loading on roofs are briefly summarised in a new Building Research Station *Digest*, No. 122, under the above title. The topic is dealt with under three headings: the characteristics of wind; pressures due to wind; and some design considerations. As the *Digest* notes, most structural engineering in this country so far as the effect of wind is concerned is governed by the revised British Standard Code of Practice, CP3, Chapter V (1952) "Loading." The current Model Byelaws of the Ministry of Housing and Local Government specify that wind loading on a building shall be calculated on the basis of this code.

Potters Bar Tunnels Completed

The construction of the new tunnels and two extra tracks at Potters Bar, on Eastern Region of British Railways, has been completed. Costing £3 million and taking nearly six years to build, the 2½ mile widening means that there are now not less than four tracks for the 21 miles from Kings Cross to the railway viaduct at Welwyn.

The major part of the work has been that of driving three new tunnels. The precast concrete lining was erected by hydraulically operated arms on the faces of the tunnel shields. The lining blocks required no fixing between rings and grouting outside the lining was not necessary in the London clay. It was the first time this form of tunnel design, evolved by Mr. H. D. Morgan, senior partner of Sir Wm. Halcrow and Partners, had been used in railway construction. The cost was estimated to be 40 per cent less than with the more conventional cast iron segments. The main civil engineering contractor was Charles Brand and Son Limited.

Dual Carriageways for Kingston Bypass

Improvements costing £1·7 million are to be made to the Kingston bypass. They will include extending the dual carriageways to the whole length of the route (at present only 3½ miles out of 8 miles are so built). Two new flyovers will be built at the Bushey and Burlington Road junctions. It is hoped that work will be started before the end of the financial year and plans are being considered for a related Esher bypass.

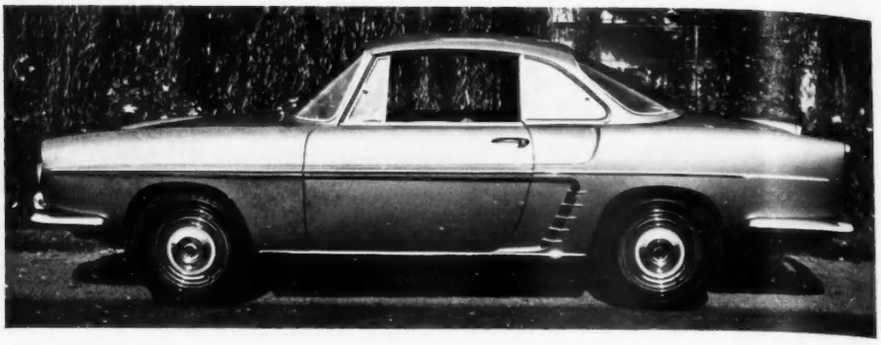
By Gordon Wilkins

RENAULT FLORIDE IN PRODUCTION

The Floride, a special bodied version of the Renault Dauphine seen in prototype form at last year's London Motor Show, is now in production. Floor structure and mechanical elements are basically those of the Dauphine saloon; body pressings are being produced by Chausson and final assembly, trim and painting is being done by Brissoneau and Lotz, at Creil.

Two versions are available, a fixed head coupé and a convertible which can have a detachable hard top. In the latter with permanent glazing and wind-up windows it is practically indistinguishable from the fixed head coupé. Wheelbase and track are unchanged but the cars are 12¾ in longer than the saloon and 5½ in lower. The fixed head coupé weighs 1,675 lb and the convertible with hard top 1,720 lb, against 1,390 lb for the saloon. This extra weight of special coachwork with luxurious seating and interior finish has resulted in disappointing performance from some other cars of this type but Renault have overcome it by modifications to the 845 cc engine which raise the output to 40 b.h.p. They are not using the Gordini engine with sloping valves which has been fitted in sports versions of the saloon but have adopted a new light-alloy cylinder head giving a higher compression ratio of 8 to 1, a larger carburettor, new inlet manifold, bigger inlet valves and a new camshaft. Buyers have the option of the normal three-speed gearbox or a four-speed gearbox with synchromesh on the upper three. Cars with the three-speed box can have the Ferlec electromagnetic clutch at extra cost. Final drive ratios are unchanged, but tyres on the Floride are larger (145 × 380), giving 15·3 m.p.h. per 1,000 r.p.m. in top gear.

The bodies are two-door unit structures in steel and are luxuriously finished. The two-colour steering wheel has two spokes and hand grips built into the rim, inspired by an aircraft control column. Behind the two main seats are two occasional seats which fold away to form a luggage platform. There is also 8·4 cu. ft of luggage space in the trunk at the front.

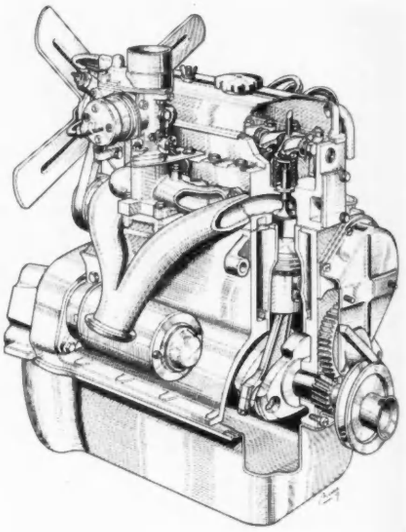


Renault Floride coupé.

Equipment includes heater, screen washer, cigarette lighter, town and country horns. Upholstery is in plastics. Export models are being fitted with 12-volt instead of 6-volt electrical equipment and this seems likely to extend to ordinary Dauphines in due course.

In an extensive road test the new model proved to have a distinctly better performance than the standard Dauphine saloon despite the extra weight and it also handles rather better. On French main roads it proved capable of averaging up to 60 m.p.h. while showing a fuel consumption of 39 to 40 m.p.g. The four-speed model accelerates from 0 to 50 m.p.h. in about 17 seconds. Maximum speeds in the gears are approximately 1st 27 m.p.h., 2nd 48 m.p.h., 3rd 65 m.p.h., and in top 77 m.p.h. Driving position, seating comfort and particularly the pedal layout are distinctly better than those on the saloon.

Retail price in France is the equivalent of about £675 but when deliveries commence in England the price will probably be raised by import duty and purchase tax to about £1,150.



(Right) The 40 b.h.p. Floride engine.

SHAMROCK SPORTS SALOON

An American, Mr. W. K. Curtis, has built in this country a prototype plastics-bodied sports car intended mainly for the American market and is now negotiating with a view to putting it into production. The chassis has a ladder type steel frame with engine, transmission, suspension and other mechanical components of the Austin A.55. The body has been moulded from Cellobond polyester resins and glass fibre. The doors, bonnet and trunk-lid are double skin units formed by bonding together two mouldings so that they present smooth surfaces inside and out. Mouldings are produced by the conventional lay-up technique and it is hoped to launch body production in southern Ireland, hence the name, the Shamrock. The car is said to weigh 1,910 lb. In view of the dependence on components bought from an existing car manufacturers and not from component producers direct, the estimated price of £900 including purchase tax appears rather optimistic.

Shamrock plastics bodied prototype with detachable hard top.

IMPROVED POWER STEERING

Rotary Valve Increases Sensitivity

Since the advent of power steering systems for automobiles, engineers have been striving to achieve a power steering unit which would incorporate the response of a manual system with the smoothness and easy operation of a power steering gear. A new hydraulic system developed by the General Motors Corporation, Saginaw, Michigan, USA, appears to have achieved this aim. This new gear, which provides hydraulic valve response in less than one degree of handwheel movement with a normal driving effort of less than 1 lb on the rim of the wheel, has a "road feel" comparable with that of a manual system. The maximum effort required on full wheel lock is said to be about 3 lb.

The main design feature of this new gear system is that it incorporates a rotary valve instead of the usual valve which functions in an axial motion. The valve body and valve spool are of conventional three way, open centre construction. The valve lands, however, run parallel to the axis rather than around the diameter of the spool, as in most valves. This construction allows the valve to be actuated by rotation of the spool within the valve body, rather than by axial movement of the worm, or through any cam type device. This results in a faster actuation of the valves.

ANOTHER FARINA

With practically all Western car manufacturing countries (and the Poles too) buying Italian body styles, very large sums of money are flowing into the studies of the leading specialists in Turin and Milan and competition is being intensified. Dr. Giuseppe Farina, former World Champion racing driver, tells me he is planning to start a styling studio to provide body designs and models for car manufacturers. It was his father, the elder brother of Pinin Farina, who ran the original family coachbuilding business, the Stabilimenti Farina. Pinin eventually left to start his own company which he now runs with his son and son-in-law and when the original company closed down Dr. Farina went into the plastics business. He plans to start his styling studies in the plastics laboratory.

HEAT FLOW RESEARCH

Analysis of Brake Drum Temperatures in Racing Cars

By T. P. NEWCOMB, M.Sc., A.Inst.P., Research Division, Ferodo Limited

In most automobiles the brake drums are composed of one material (cast iron) and the temperature reached at the friction surface or at any point in the drum reduces to considering the linear flow of heat through an infinite slab between parallel boundaries, in which one face is subjected to a thermal flux which decreases linearly with time (i.e. decelerations are uniform), while there is no flow of heat at the other surface (external cooling is ignored). The errors introduced by considering the cylindrical portion of the drum to be developed into a rectangular plate and the heat flow to be uni-dimensional are small enough to be neglected. Uniform contact is assumed to exist between drum and lining and the solution derived will thus only give the instantaneous average surface temperature during braking. Solutions to the above problem have been presented previously by Bannister[1] using the method of images; Odier and Leutard[2–4] using the method of Fourier series and by Newcomb[5–7] using the method of the Laplace transformation. The last authors have also shown that the theoretical results are in good agreement with experimental measurements.

With racing cars and many Continental high performance production models, however, the brake drums are often composed of two parts, an inner cylinder which is thin and made of cast iron and a much thicker outer layer of light material with a high thermal conductivity (e.g. aluminium). The aluminium section is generally finned but for simplicity in the following analysis it is assumed that all the material extends to the external fin diameter. The cast iron layer is essential because of its resistance to scoring, maintenance of strength at elevated temperatures, stable coefficient of friction, ability to resist deformation, resistance to heat checking and long life with normal wear. The presence of the thick layer of high conductivity material causes heat to be conducted away more rapidly than with cast iron alone and accordingly the maximum temperature attained should be lower than with ordinary brake drums.

Consequently, it is of interest to determine the temperature distribution in a bimetallic drum in order to show quantitatively the advantages of using such a drum compared with a cast iron brake drum of equivalent weight when the heat generated is identical in both cases. Thus the problem discussed in this paper concerns the linear flow of heat in a bimetallic body when one surface of the cast iron layer is subjected to a thermal flux Q $(1 - a\,t)$ whilst there is no flow of heat at the other parallel boundary. Provided the brake application is of short duration (up to 10 secs), all the heat can be assumed to flow into the drum with little error resulting. The problem of repeated braking at regular intervals is also discussed.

Heat Problem and Application of its Solution

Consider the linear flow of heat in a composite solid consisting of two infinite slabs between parallel planes, the complete body being initially at zero temperature. The first medium lies in the region $0 < x < d_1$ and has physical properties K_1, ρ_1, c_1, α_1, θ_1 while $d_1 < x < d_2$ denotes the region of the second medium with physical properties K_2, ρ_2, c_2, α_2, θ_2. The quantities K, ρ, c, α, θ with suffixes for which ever solid is considered refer respectively to the thermal conductivity, density, specific heat, thermal diffusivity and the temperature rise at any point x in the medium concerned. The boundary $x = 0$ is subjected to a thermal flux Q $(1 - a\,t)$ uniformly distributed over the plane while at the boundary $x = d_2$ there is no flow of heat perpendicular to the plane. Q represents the flux of heat entering this body. At the surface of separation $x = d_1$, between medium (1) and medium (2), it is assumed that there is no contact resistance and that continuity of heat flux and temperature exists across the boundary. Fig. 1 shows a diagrammatic sketch of the arrangement.

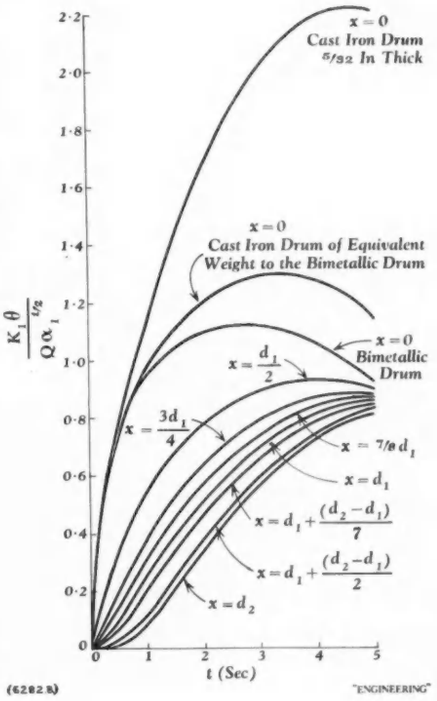
Using the boundary conditions stated above, solutions are derived in the appendix giving θ_1 and θ_2. The quantities Q and a for any drum of the vehicle in a single brake application to rest on a level track are given by the expressions

$$Q = \frac{y f u W}{2 \pi g D w J} \quad \text{and} \quad a = \frac{f}{u} = \frac{1}{T} \quad (1)$$

where W = weight of car
f = uniform deceleration of car
u = initial speed of car
g = acceleration due to gravity
D = internal drum diameter
w = shoe width
T = total stopping time of brake application
J = mechanical equivalent of heat
y = the proportion of the total braking force transmitted to the axle of which ever wheels are considered (y is generally 0·6 for the front and 0·4 for the rear wheels),

all units being expressed in the c.g.s. system.

Thus, given Q, a, and the physical properties of the contacting bodies, the temperature rise at the interface of the drum and lining or inside either metallic portion of the drum at any instant during a single brake application to rest can be determined from equations (13) and (14). [See appendix.]



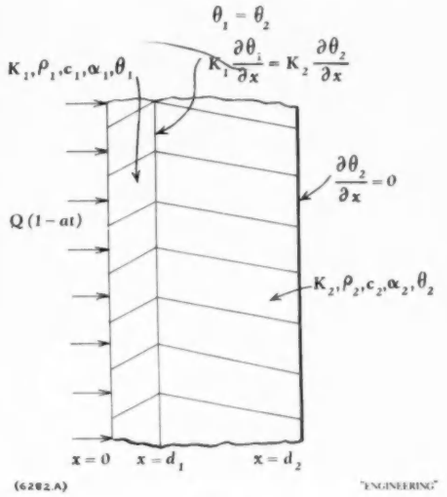


Fig. 1

In a typical practical case $d_1 = \frac{5}{32}$ in (0·3906 cm), $K_1 = 0{\cdot}12$ cal cm^{-1} s^{-1} °C^{-1}, $\alpha_1 = 0{\cdot}12$ cm^2 s^{-1}, $d_2 - d_1 = \frac{11}{32}$ in (1·094 cm), $K_2 = 0{\cdot}48$ cal cm^{-1} s^{-1} °C^{-1}, $\alpha_2 = 0{\cdot}86$ cm^2 s^{-1}, $\rho_2 = 2{\cdot}75$ gm cm^{-3} and for a five and ten second time of brake application, from equations (13) and (14), values of $\frac{K_1\theta}{Q\alpha_1^{\frac{1}{2}}}$ at various times during the stop and at different positions inside the brake drum have been determined and

Fig. 2 (left) Variation of $\frac{K_1\theta}{Q\,\alpha_1^{\frac{1}{2}}}$ *at different depths (x) inside a bimetallic drum during a 5 sec brake application.*

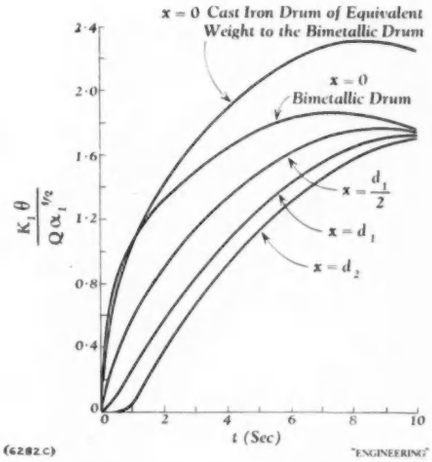


Fig. 3 (above) Variation of $\frac{K\theta_1}{Q\,\alpha_1^{\frac{1}{2}}}$ *at different depths (x) inside a bimetallic drum during a 10 sec brake application.*

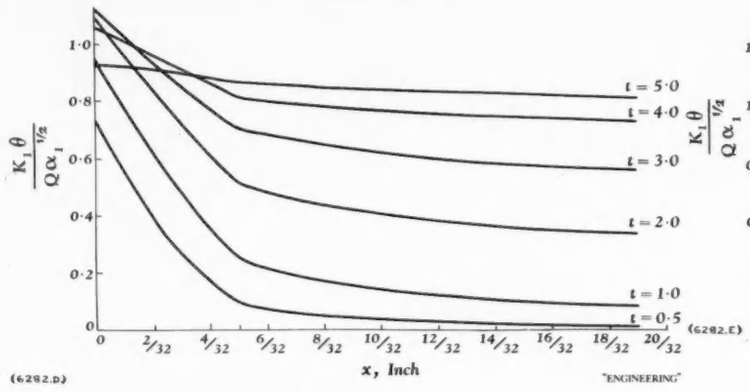


Fig. 4 Variation of $\frac{K_1\theta}{Q\alpha_1^{\frac{1}{2}}}$ at different depths inside a bimetallic drum for various times during a 5 sec brake application.

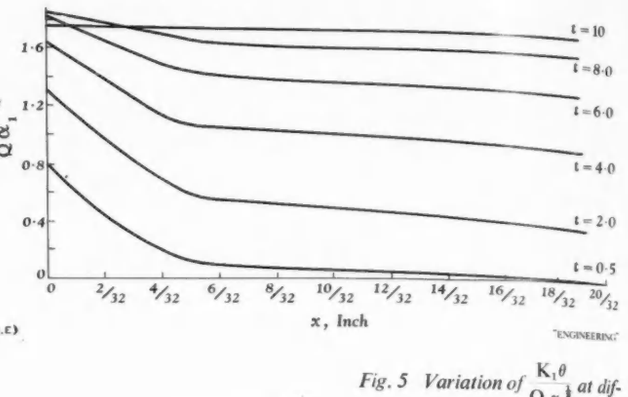


Fig. 5 Variation of $\frac{K_1\theta}{Q\alpha_1^{\frac{1}{2}}}$ at different depths inside a bimetallic drum for various times during a 10 sec brake application.

these are shown graphically in Figs. 2 and 3 respectively. For comparison, the values of $\frac{K_1\theta}{Q\alpha_1^{\frac{1}{2}}}$ at the interface of drum and lining are shown when the cast iron drum is assumed to be $\frac{6}{32}$ in in thickness and when the cast iron drum is of equivalent weight to that of the bimetallic drum. The latter curves have been determined from the following expression obtained by Newcomb,[5] which states that for a semi-infinite slab

$$\frac{K_1\theta}{Q\alpha_1^{\frac{1}{2}}} = \frac{2t^{\frac{1}{2}}}{\pi^{\frac{1}{2}}}(1 - \tfrac{2}{3}\,at) + 4t^{\frac{1}{2}}\sum_{n=1}^{\infty} i^n \operatorname{erf} c\,2n\lambda - 16\,at^{\frac{3}{2}}\sum_{n=1}^{\infty} i^3 \operatorname{erf} c\,2n\lambda \quad . \quad (2)$$

where $\lambda = \dfrac{d_1}{2(\alpha_1 t)^{\frac{1}{2}}}$ and

$$i^n \operatorname{erf} cx = \int_x^{\infty} i^{n-1} \operatorname{erf} cy\,dy \quad n = 1, 2, 3 \ldots$$

with

$$i^0 \operatorname{erf} cx = \operatorname{erf} cx = \frac{2}{\pi^{\frac{1}{2}}}\int_x^{\infty} \exp(-y^2)\,dy$$

The function $i^n \operatorname{erf} cx$ for various values of n and x is given in tabular form by Carslaw and Jaeger.[8]

The curves in Figs. 2 and 3 show that, for the same Q and a, the maximum temperature rise attained at the working surface of a cast iron drum of equivalent weight is approximately 1·2 times that of a bimetallic drum. Thus if a cast iron drum reached a maximum temperature of 600° C, its equivalent weight as a bimetallic drum would attain a maximum temperature of approximately 500° C in a single brake application. Figs. 4 and 5 show the temperature gradient across the bimetallic drum at different times during the brake application. These curves indicate that when initially the brakes are applied, high temperature gradients exist near the friction surface of the drum. Consequently, high thermal stresses must occur in this region and thus surface fatigue is equally prone with bimetallic drums as with ordinary cast iron drums.

Repeated Braking

During a single brake application the rise in average temperature is given by the equation

$$\Delta\theta = \frac{\int_0^t Q\,dt}{c\,\rho\,d} = \frac{Q}{c\,\rho\,d}\left(t - \frac{at^2}{2}\right) = \frac{QT}{2\,c\,\rho\,d} \quad (3)$$

at the end of a brake application, which assumes that the heat generated prior to time t is being spread uniformly throughout the cylindrical portion of the drum. This value for the average temperature is almost identical with the friction surface temperature at the end of the brake application and consequently the drum is at a uniform temperature soon after a stop. The drum is then cooled largely by convection of the heat to the atmosphere, the rate obeying the Newtonian law of cooling (Odier[9] and Newcomb[7]). The losses by conduction through the hub (the mass of which is assumed to be small in comparison to that of the drum) and by radiation only amount to the order of a few per cent. Further braking produces transients similar to the previous one if the heat generated is identical and consequently the drum attains a higher average temperature. With repeated braking this process continues until an equilibrium is reached between the heat input and the heat loss to the atmosphere.

Newton's law of cooling states that

$$\theta - \theta_o = (\theta'' - \theta_o)\exp(-bt) \quad . \quad (4)$$

where θ'' = average temperature of drum just after braking
θ_o = ambient temperature
θ = average temperature at any instant t during cooling

$$b = \frac{A\,h}{W\,c}$$

A = exposed surface area
W = weight of drum
h = coefficient of heat transfer
c = specific heat of drum.

Applying the above law of cooling to intermittent braking, the analysis of the temperature rise is as follows:—

First stop

Initially $\theta_1' = \theta_o$
Finally $\theta_1'' = \theta_o + \Delta\theta$
where $\Delta\theta$ is the mean temperature increase during braking $= \dfrac{(Q\ T)}{2c\ \rho\ d'}$

θ' is the average drum temperature at the commencement of each brake application and suffixes refer to the particular application.

Second stop

Initially $\theta_2' = \theta_o + \Delta\theta\exp(-b\,t_o)$
Finally $\theta_2'' = \theta_o + \Delta\theta\{1 + \exp(-b\,t_o)\}$
where t_o is the regular interval between braking.

nth stop

Initially $\theta_n' = \theta_n'' - \Delta\theta = \theta_o + \Delta\theta\left\{\dfrac{\exp(-b\,t_o) - \exp(-n\,b\,t_o)}{1 - \exp(-b\,t_o)}\right\}$ (5)

Finally $\theta_n'' = \theta_o + \Delta\theta\left\{\dfrac{1 - \exp(-n\,b\,t_o)}{1 - \exp(-b\,t_o)}\right\}$. (6)

Ultimately, the steady state is reached (i.e., n is large) and the limiting temperatures are given by

$$\theta'_{\text{limit}} = \theta_o + \frac{\Delta\theta}{(\exp(b\,t_o) - 1)} \quad (7)$$

and $$\theta''_{\text{limit}} = \theta_o + \frac{\Delta\theta}{(1 - \exp(-b\,t_o))} \quad (8)$$

Since b is generally small, by expanding the first terms of the exponential series, the equation for θ''_{limit} becomes

$$\theta''_{\text{limit}} = \theta_o + \frac{2\Delta\theta}{b\,t_o(2 - b\,t_o)} \quad . \quad (9)$$

$$= \theta_o + \frac{W\,c\,Q\,T}{h\,t_o(2W\,c - A\,h\,t_o)} \quad . \quad (10)$$

If we consider two drums of equal weight one of which is cast iron ($c = 0{\cdot}136$) and the other composite ($c = 0{\cdot}19$) both of which are being braked at the same Q, T, t_o, h, then the above equations show that, since b is very small in practice, little reduction is affected on the limiting temperature by using the composite drum of greater specific heat, but use of the latter does reduce the rate of temperature rise during repeated braking. For example, if $\Delta\theta$ is the rise in average temperature of the cast iron drum, equation (3) shows that the rise in average temperature of the bimetallic drum in an individual brake application is 0·716 $\Delta\theta$ when the same Q, a and t_o applies in both cases. Furthermore, the value of b of a bimetallic drum is 0·716, that of a cast iron drum of the same weight. Fig. 6 shows graphs of $\dfrac{\theta_n'' - \theta_o}{\Delta\theta}$ versus n, where $t_o = 30$ sec, and $b = 0{\cdot}005$ and $\Delta\theta$ both refer to the cast iron drum. These curves indicate that for a small number of brake applications a considerable reduction in the rate of temperature rise can be obtained by using a bimetallic drum in place of an ordinary

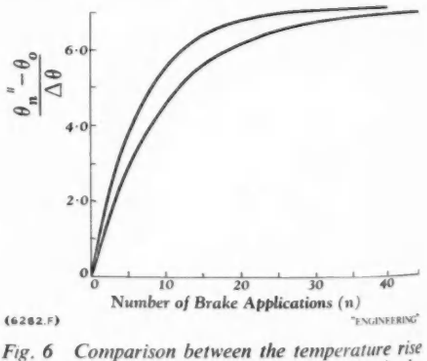


Fig. 6 Comparison between the temperature rise ($\theta_n'' - \theta_o$) of a cast iron and a bimetallic brake drum during regular repeated brake applications under identical energy conditions.

cast iron drum although eventually they both attain the same limiting temperature.

Acknowledgments

The author wishes to thank Dr. R. T. Spurr and Mr. A. Stinton of the Research Division of Ferodo Limited for assistance and criticism, and the directors of Ferodo Limited for permission to publish this paper.

Appendix

Solution to the Heat Conduction Problem

The partial differential equations to be solved are

$$\frac{\partial^2\theta_1}{\partial x^2} - \frac{1}{\alpha_1}\frac{\partial\theta_1}{\partial t} = 0, \quad 0 < x < d_1,\ t > 0 \ . \ (1)$$

$$\frac{\partial^2\theta_2}{\partial x^2} - \frac{1}{\alpha_2}\frac{\partial\theta_2}{\partial t} = 0, \quad d_2 > x > d_1,\ t > 0 \ . \ (2)$$

with the boundary conditions.

$$K_1\frac{\partial\theta_1}{\partial x} = -\,Q(1 - a\,t) \text{ at } x = 0 \ . \ (3)$$

$$K_1\frac{\partial\theta_1}{\partial x} = K_2\frac{\delta\theta_2}{\delta x} \text{ at } x = d_1 \ . \ (4)$$

$$\theta_1 = \theta_2 \quad \text{at } x = d_1 \ - \ - \ (5)$$

$$\frac{\partial\theta_2}{\partial x} = 0 \qquad \text{at } x = d_2 \ . \ (6)$$

Introducing the Laplace transform defined as

$$\bar{\theta} = \int_0^\infty \exp(-p\,t)\,\theta(x,t)\,dt \ . \ (7)$$

he subsidiary equations become

$$\frac{d^2\bar{\theta}_1}{dx^2} - q_1{}^2\bar{\theta}_1 = 0, \quad 0 < x < d_1 \ . \ (8)$$

$$\frac{d^2\bar{\theta}_2}{dx^2} - q_2{}^2\bar{\theta}_2 = 0, \quad d_1 < x < d_2 \ . \ (9)$$

$$\text{where } q_2{}^2 = \frac{p}{\alpha_1} \text{ and } q_2{}^2 = \frac{p}{\alpha_2} \ . \ (10)$$

Solving equations (8) and (9) in the usual manner and applying the transformed boundary conditions of equations (3) to (6), it can be shown that $\bar{\theta}_1$ and $\bar{\theta}_2$ are given by equations (11) and (12).

See Equations 11 and 12 in block above

Applying in the usual way the Inversion Theorem for the Laplace Transformation to equations (11) and (12) gives expressions for θ_1 and θ_2

See Equations 13 and 14 in block above

Thus, if Q and a and the physical properties of the contacting bodies are known, the temperature rise at the interface of drum and lining or inside either metallic portion of the drum may be determined from equations (13) and (14). Consider the special case when $d_1 = d_2 = d$ and $\alpha_1 = \alpha_2 = \alpha$. At the interface of drum and lining

$$w = 0, \quad y = \frac{d}{\alpha^{\frac{1}{2}}}, \quad z = \frac{d}{\alpha^{\frac{1}{2}}} \quad \text{and} \quad \beta = \frac{n\,\pi\,\alpha^{\frac{1}{2}}}{d}$$

$$(n = 1, 2, 3 \ldots)$$

and equation (13) reduces to

$$\theta = \frac{Q\,\alpha}{K\,d}\left[t\left(1 - \frac{a\,t}{2}\right) + \frac{d^2}{3\alpha}(1 - a\,t) + \frac{a\,d^4}{45\alpha^2} - \frac{2d^2}{\pi^2\alpha}\sum_{n=1}^{\infty}\frac{1}{n^2}\exp\left(-\frac{\pi^2\alpha\,t}{d^2}\right) - \frac{2a\,d^4}{\pi^4\alpha^2}\sum_{n=1}^{\infty}\frac{1}{n^4}\exp\left(-\frac{\pi^2\alpha\,t}{d^2}\right)\right] \ (15)$$

which is the expression obtained by Odier and Leutard[4] for the temperature rise at the surface of an infinite slab at which exists a thermal flux which decreases linearly with time.

$$\bar{\theta}_1 = \frac{Q\alpha_1{}^{\frac{1}{2}}}{K_1}\left(\frac{1}{p^{\frac{3}{2}}} - \frac{a}{p^{\frac{5}{2}}}\right)\frac{\cosh q_2(d_2 - d_1)\cosh q_1(d_1 - x) + \sigma\sinh q_1(d_1 - x)\sinh q_2(d_2 - d_1)}{\sinh q_1 d_1\cosh q_2(d_2 - d_1) + \sigma\cosh q_1 d_1\sinh q_2(d_2 - d_1)} \ . \ (11)$$

$$\bar{\theta}_2 = \frac{Q\,\alpha_1{}^{\frac{1}{2}}}{K_1}\left(\frac{1}{p^{\frac{3}{2}}} - \frac{a}{p^{\frac{5}{2}}}\right)\frac{\cosh q_2(d_2 - x)}{\sinh q_1 d_1\cosh q_2(d_2 - d_1) + \sigma\cosh q_1 d_1\sinh q_2(d_2 - d_1)} \ . \ (12)$$

where $$\sigma = \frac{K_2}{K_1}\left(\frac{\alpha_1}{\alpha_2}\right)^{\frac{1}{2}}$$

Equations 11 and 12

$$\theta_1 = \frac{Q\,\alpha_1{}^{\frac{1}{2}}}{K_1(y + \sigma w)}\left(t\left(1 - \frac{a\,t}{2}\right) + \frac{(1 - a\,t)}{2}(w^2 + z^2 + 2\sigma w z) - \frac{a}{24}(w^4 + 6w^2z^2 + z^4 + 4\sigma w z(w^2 + z^2)) - \frac{1}{120(y + \sigma w)}\Big[20(y^3 + 3wy(w + \sigma y) + \sigma w^3)\left\{1 - a\left(t + \frac{w^2 + 2\sigma w z + z^2}{2}\right)\right\} - a\{y^5 + 10w^2y^2(y + \sigma w) + 5wy(w^3 + \sigma y^3) + \sigma w^5\}\Big] - \frac{a}{36(y + \sigma w)^2}\{y^3 + 3wy(w + \sigma y) + \sigma w^3\}^2\right)$$

$$- 2\frac{Q\,\alpha_1{}^{\frac{1}{2}}}{K_1}\sum_{m=1}^{\infty}\left(\frac{1}{\beta_m{}^2} + \frac{a}{\beta_m{}^4}\right)\left\{\frac{\cos\beta_m w\cos\beta_m z - \sigma\sin\beta_m w\sin\beta_m z}{(y + \sigma w)\cos\beta_m y\cos\beta_m w - (w + y\sigma)\sin\beta_m y\sin\beta_m w)}\right\}\exp(-\beta_m{}^2 t) \ - \ - \ - \ (13)$$

and $$\theta_2 = \frac{Q\,\alpha_1{}^{\frac{1}{2}}}{K_1(y + \sigma w)}\left(t\left(1 - \frac{a\,t}{2}\right) + \tfrac{1}{2}(1 - a\,t)\,u^2 - \frac{a\,u^4}{24} - \frac{1}{120(y + \sigma w)}[20(y^3 + 3wy(w + \sigma y) + \sigma w^3)\left\{1 - a\left(t + \frac{u^2}{2}\right)\right\} - a\{y^5 + 10w^2y^2(y + \sigma w) + 5wy(w^3 + \sigma y^3) + \sigma w^5\}] - \frac{a}{36(y + \sigma w)^2}\{y^3 + 3wy(w + y\sigma) + \sigma w^3\}^2\right)$$

$$- 2\frac{Q\,\alpha_1{}^{\frac{1}{2}}}{K_1}\sum_{m=1}^{\infty}\left(\frac{1}{\beta_m{}^2} + \frac{a}{\beta_m{}^4}\right)\left\{\frac{\cos\beta_m u}{(y + \sigma w)\cos\beta_m y\cos\beta_m w - (w + y\sigma)\sin\beta_m y\sin\beta_m w}\right\}\exp(-\beta_m{}^2 t) \ . \ . \ . \ (14)$$

where $$w = \frac{(d_2 - d_1)}{\alpha_2{}^{\frac{1}{2}}} \qquad y = \frac{d_1}{\alpha_1{}^{\frac{1}{2}}} \qquad z = \frac{d_1 - x}{\alpha_1{}^{\frac{1}{2}}} \qquad u = \frac{d_2 - x}{\alpha_2{}^{\frac{1}{2}}}$$

and $\pm\beta_m$, $m = 1, 2, 3 \ldots$ are the roots of the equation

$$\cos\beta w\sin\beta y + \sigma\cos\beta y\sin\beta w = 0$$

and these roots are real and simple.

Equations 13 and 14

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RADIO TELEPHONE BY TROPOSPHERIC SCATTERING

The separation of West Berlin from the rest of the Federal Republic has posed a serious problem for the telephone engineers. A no-telephone man's land 100 miles wide, separates the two areas. In the early days the British Forces set up their own radio relay system. Later on a 24 channel short-wave radio station made by Siemens and Halske of Munich was installed, which operated from a 490 ft high mast in the Nicolassee district. This station did very well up to 1955 when the introduction of direct dialling between major German cities caused overloading at peak hours. Last year it was decided to install a new radio link of greater capacity. This is being constructed by Telefunken of Berlin, and Siemens and Halske, and can carry up to 120 conversations at the same time. It operates on the "scatter transmission" system developed in the United States. This system is based on the "scatter" effect accompanying the emission of ultra-high frequency waves. In transmission of radio signals of this kind some of the carrier waves are reflected by moisture or layers of cooler or warmer air in the troposphere and the ionosphere. The link between West Berlin and West Germany operates on a wavelength of 15 centimetres using "scattered" waves reflected from the troposphere.

When it comes into operation shortly the new link-up will relieve West Berlin's telephone congestion and it is hoped to provide sufficient capacity for some time to come.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk(*). For details of events not included below, reference should be made to ENGINEERING, *27 March, page 396, and 24 April, page 541. Organisers are invited to send particulars of coming events to the Editor.*

British Electrical Power Convention.—Mon., 1 June, to Sat., 6 June, at Torquay. Organised by the British Electrical Power Convention, 26-27 Cockspur Street, London, SW1. Tel. WHItehall 1928. An **Electrical Exhibition** in connection with the convention will be held at Torquay during the same period. Organisers: British Electrical Development Association, 2 Savoy Hill, London, WC2. Tel. TEMple Bar 9434.

***Nickel, Platinum, Metals and Spheroidal Graphite Iron, Exhibition.**—Tues., 2 June, to Fri., 5 June, at Cutlers' Hall, Sheffield. Organised by the Mond Nickel Co., Ltd., Thames House, Millbank, London, SW1. Tel. VICtoria 3888.

***Ceramics, Technical Congress on.**—Wed., 3 June, to Fri., 5 June, in Paris. Organised by the Société Française de Céramique, 44 Rue Copernic, Paris 16.

Bath and West Agricultural Show.—Wed., 3 June, to Sat., 6 June, on the Show Site, Yeovil. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont Street, Bath. Tel. Bath 3010.

***Standards in Industry, Conference on Application of.**—Thurs., 4 June, at Connaught Rooms, Great Queen Street, London, WC2. Under auspices of the Institution of Production Engineers and the British Standards Institution. BSI offices: 2 Park Street, London, W1. Tel. MAYfair 9000.

San Francisco International Fair, First.—Thurs., 4 June, to Sun., 14 June, at Cow Palace, San Francisco. Offices: 325 Pacific Avenue, San Francisco 11, Calif, USA.

Helsingborg Annual Trade Fair (Expo Oresund).—Fri., 5 June, to Sun., 14 June, at Helsingborg. Held in collaboration with the Swedish Federation of Commercial Agents. Apply to Helsingborg Exhibitions Co., Ltd., Helsingborg, Sweden.

***Electromagnetic Theory, Symposium on.**—Fri., 5 June, to Sat., 20 June, at Toronto. Apply to Professor George Sinclair, The University, Toronto 5, Ontario, Canada.

***Institution of Production Engineers, Regional Conference.**—Sat., 6 June, at offices of Ericsson Telephones Ltd., Beeston, Nottingham. Theme: "Communication of Ideas in Production: Its Importance and Improvements." Institution offices: 10 Chesterfield Street, London, W1. Tel. GROsvenor 5254.

PUBLIC CLEANSING

***Institute of Public Cleansing, Conference.**—Tues., 9 June, to Fri., 12 June, at Brighton. Offices of the Institute: 8 Orange Street, London, WC.2. Tel. WHItehall 2604.

Institute of British Foundrymen, Annual Conference.—Tues., 9 June, to Fri., 12 June, at the Spa Ballroom and the Library, Vernon Road, Scarborough. Offices of the Institute: St. John Street Chambers, Deansgate, Manchester 3. Tel. Blackfriars 6178.

Material Handling Institute's Exposition.—Tues., 9 June, to Fri., 12 June, at the Public Auditorium, Cleveland. Organisers: Hanson and Shea, Inc., 1 Gateway Center, Pittsburgh 22, Pa., USA.

***Operational Research Society's Second Annual Conference.**—Wed., 10 June, to Fri., 12 June, at the Old Swan Hotel, Harrogate. Fee, £15. Apply to the Society at 64 Cannon Street, London, EC4. Tel. CITy 1800. (Additional information.)

Building Plant Exhibition.—Wed., 10 June, to Wed., 17 June, at Greenford, Middlesex. Apply to room 105A, Ministry of Works, Lambeth Bridge House, London, SE1. Tel. RELiance 7611, ext. 1177.

Oregon Centennial Exposition, Portland.—Wed., 10 June, to Thurs., 17 Sept. **International Trade Fair.**—Wed., 10 June, to Wed., 24 June. At the Pacific International Livestock Pavilion, Portland. Organised by the Oregon Centennial Commission, 400 Jackson Tower, Portland, Oregon, USA. United Kingdom inquiries should be made to Export Publicity and Fairs Branch, Board of Trade, Theobalds Road, London, EC1. Tel. CHAncery 4411.

International Society of Aviation Writers, General Meeting.—Fri., 12 June, to Fri., 19 June, in Paris. Apply to the Society's secretary-general, 25 Farmcote Road, Don Mills, Ontario, Canada.

Aeronautical Exhibition, 23rd International.—Fri., 12 June, to Sun., 21 June, at Le Bourget Airport, Paris. Organised by the Salon International de l'Aeronautique, 6 Rue Galilée, Paris 16e.

***French Electrical Equipment Exhibition (ELECTRAMA).**—Fri., 12 June, to Fri., 26 June, in Paris. "First general exhibition of the French electrical engineering industries and of the applications of electricity in modern life." Offices: 14 Rue de Magdebourg, Paris 16e. (Alteration of closing date.)

Institution of Heating and Ventilating Engineers, Summer Meeting.—Sat., 13 June, to Wed., 17 June, at the North British Hotel, Edinburgh. Institution's offices: 49 Cadogan Square, London, SW1. Tel. SLOane 3158.

United States International Book Exhibition, Fourth.—Sun., 14 June, to Thurs., 18 June, at the Shoreham Hotel, Washington, DC, USA. Takes place at the **1959 Convention and Trade Exhibition of the American Booksellers' Association.** An integral part of the book exhibition will be the **International Periodical Exhibition.** Organisers: A. P. Wales Organization, the European head office of which is 36-38 Southampton Street, London, WC2. Tel. TEMple Bar 8947.

***X-Ray Microscopy and X-Ray Microanalysis, Second International Symposium on.**—Mon., 15 June, to Wed., 17 June, in Stockholm. Apply to Dr. G. Hoglund, Institutionen for Medicinsk Fysik, Karolinska Institutet, Stockholm 60, Sweden.

International Congress on Combustion Engines.—Mon., 15 June, to Sat., 20 June, at Wiesbaden, Germany. Theme: "Diesel Engines and Gas Turbines up to 1,500 h.p.: Current Problems Concerning Their Design, Production, Development and Running on Site." Apply to the secretary to the national committee, International Congress on Combustion Engines, 6 Grafton Street, London, W1. Tel. HYDe Park 5107.

INFORMATION PROCESSING

***Information Processing, International Conference on.**—Mon., 15 June, to Sat., 20 June, in Paris. Organised by the United Nations Educational, Scientific and Cultural Organisation. An **International Exhibition of Data Processing Equipment (Auto-Math 59)** will be held at the Grand Palais, Paris, from Sat., 13 June, to Tues., 23 June. Inquires in UK should be addressed to the honorary secretary, Group B, British Conference on Automation and Computation, c/o the Institution of Electrical Engineers, Savoy Place, London, WC2 (Tel. TEMple Bar 7676); and other inquiries to the Information Processing Department, Department of Natural Sciences, UNESCO Secretariat, Paris. (Additional information.)

Nuclear and Electronics Congress and Exhibition, Sixth.—Mon., 15 June, to Sun., 5 July, at Rome. Apply Rassegna Internazionale Electronica Nucleare, Via della Scofa 14, Rome.

Three Counties Agricultural Show.—Tues., 16 June, to Thurs., 18 June, at Malvern. Offices: Three Counties Showground, Malvern, Worcestershire. Tel. Malvern 2231.

International Conference on the Chemical Arts.—Tues., 16 June, to Tues., 30 June, in Paris. Offices: 28 Rue Saint-Dominique, Paris 17e.

***Ergonomics in Industry, Conference on.**—Wed. and Thurs., 17 and 18 June, at Brunel College of Technology. Apply to Mr. Robert Borger, Brunel College of Technology, Acton, London, W3. Tel. ACTon 6661.

***Nuclear Instrumentation, Second Symposium on.**—Wed., 17 June, to Fri., 19 June, at Idaho Falls, Idaho, USA. Organised by the Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa., USA.

Plastics Exhibition and Convention, International (formerly the **British Plastics Exhibition and Convention**).—Wed., 17 June, to Sat., 27 June, at Olympia, London, W14. Organised, with the support of the British Plastics Federation, 47-48 Piccadilly, London, W1 (Tel. REGent 4681), by *British Plastics*, Dorset House, Stamford Street, London, SE1. Tel. WATerloo 3333.

QUALITY IN INDUSTRY

Quality in Industry, Conference.—Thurs. and Fri., 18 and 19 June, at the Palace Hotel, Buxton. Fee: 5 guineas, inc. papers, light refreshments, etc. Organised jointly by the Institution of Production Engineers, the Institution of Engineering Inspection, and the British Productivity Council. Apply to the conference secretary, Institution of Production Engineers, 10 Chesterfield Street, London, W1. Tel. GROsvenor 5254.

Chemical Exhibition, Fifth International.—Thurs., 18 June, to Mon., 29 June, at the Exhibition Grounds, Porte de Versailles, Paris. *Agents in United Kingdom:* Butler's Advertising Service Ltd., 22 St. Giles High Street, London, WC2. Tel. TEMple Bar 5905.

Safety and Factory Efficiency Exhibition.—Fri., 19 June, to Fri., 26 June, at Bingley Hall, Birmingham. Offices: 71 Broad Street, Birmingham 15. Tel. Midland 8073.

***ASTM Annual Meeting.**—Sun., 21 June, to Fri., 26 June, at Atlantic City, NJ, USA. Organised by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., USA.

***Molecular Quantum Mechanics, International Conference on.**—Sun., 21 June, to Sat., 27 June, at Boulder, Colarado, USA. Apply to Dr. R. G. Parr, Carnegie Institute of Technology, Pittsburgh, Pa., USA.

***Petroleum Equipment, Third European Conference on.**—Mon., 22 June, to Thurs., 25 June, in Paris. Organised by the Federation of European Petroleum Equipment Manufacturers. Apply to Mr. G. C. Carr, Council of British Manufacturers of Petroleum Equipment, 2 Princes Row, London, SW1. Tel. VICtoria 0017.

Air Pollution Control Association, Annual Meeting.—Mon., 22 June, to Fri., 26 June, at the Hotel Statler, Los Angeles, Calif., USA. Association offices: 4400 Fifth Avenue, Pittsburgh, Pa., USA.

***Suggestion Schemes in British Industry, Conference.**—Tues., 23 June, at 48 Bryanston Square, London, W1. Fees, £2 12*s* 6*d* and £3 3*s* 0*d*. Organised by the Industrial Welfare Society, 48 Bryanston Square, London, W1. Tel. AMBassador 2401.

Royal Highland Show.—Tues., 23 June, to Fri., 26 June, in Aberdeen. Organised by the Royal Highland and Agricultural Society of Scotland, 8 Eglinton Crescent, Edinburgh 12. Tel. Edinburgh Central 6106.

***Welding Technology for Power Supply, Conference on.**—Tues., 23 June, to Fri., 26 June, in Berlin. Organised by the Deutscher Verband für Schweisstechnik e.V., 23 Harkortstrasse, Düsseldorf, Germany.

***Royal Institution of Chartered Surveyors, Third Annual Conference.**—Tues., 23 June, to Sat., 27 June, at The University, St. Andrews, Scotland. Institution's offices: 12 Great George Street, London, SW1. Tel. WHItehall 5322.

Medical Electronics, Second International Conference on.—Wed., 24 June, to Sat., 27 June, at the new UNESCO Building, Paris. Apply to Dr. C. N. Smyth, University College Hospital, Gower Street, London, WC1.

***Electric Arc in Welding, Conference on.**—Thurs., 25 June, at The University, Birmingham. Fee: 1 guinea. Apply to the Department of Industrial Metallurgy, The University, Edgbaston, Birmingham 15.

Gases and Volatile Substances, Conference on.—Thurs. and Fri., 25 and 26 June, in Paris, during the course of the International Conference on the Chemical Arts. Organised by the Institut Français des Combustibles et de l'Energie, 3 Rue Henri-Heine, Paris 16e.

Institution of Mechanical Engineers, Summer Meeting.—Mon., 29 June, to Thurs., 2 July, in Zürich. It is hoped that additional pleasure excursions will take place on 3 July. Institution offices: 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

***International Electrotechnical Commission, General Meeting.**—Tues., 30 June, to Fri., 10 July, at Madrid. Commission's offices: 1-2 Rue de Varembe, Geneva, Switzerland.

Television Engineering in Science, Industry and Broadcasting, Convention on.—Wed., 1 July, to Sun., 5 July, at The University, Cambridge. Arranged by the British Institution of Radio Engineers, 9 Bedford Square, London, WC1. Tel. MUSeum 1901.

Chicago International Trade Fair.—Thurs., 2 July, to Sat., 18 July, at the Navy Pier Exhibition Hall, Chicago. Organised by the Chicago Association of Commerce and Industry, 30 West Monroe, Chicago 3, Ill., USA.

Fishing and Allied Industries Exhibition, 19th International.—Sat., 4 July, to Sun., 19 July, at Ancona, Italy. Apply to the Ancona Chamber of Commerce, Ancona, Italy.

Iron and Steel Institute, Special Meeting.—Mon., 6 July, to Fri., 10 July, on the North East Coast. Institute's offices: 4 Grosvenor Gardens, London, SW1. Tel. SLOane 0061.

X-RAY DIFFRACTION

***X-Ray Diffraction and Spectrography, Conference.**—Mon., 6 July, to Fri., 10 July, at the Imperial College of Science and Technology, South Kensington, London, SW7. Apply to the conference secretary, Research and Control Instruments Ltd., 207 King's Cross Road, London, WC1. Tel. TERminus 8444.

Royal Show.—Tues., 7 July, to Fri., 10 July, at Woodstock, near Oxford. Organised by the Royal Agricultural Society of England, 35 Belgrave Square, London, SW1. Tel. BELgravia 5323.

***Aluminium in Building, Symposium.**—Thurs. and Fri., 9 and 10 July, at the Royal Institute of British Architects, 66 Portland Place, London, W1. Organised by the Aluminium Development Association, 33 Grosvenor Street, London, W1. Tel. MAYfair 7501.

Electronics Exhibition and Convention, 14th Annual.—Thurs., 9 July, to Wed., 15 July, at the Manchester College of Science and Technology. Organised by the Northern Division of the Institution of Electronics. Institution offices: 78 Shaw Road, Thornham, Rochdale. Tel. Oldham Main 6661.

Underground Machinery Manufacturers Council, Exhibition.—Thurs., 9 July, to Sat., 18 July, at Olympia, London, W14. Sponsored by the Council of Underground Machinery Manufacturers, c/o Peat, Marwick, Mitchell and Co. (P.O. Box 121), 301 Glossop Road, Sheffield 10. Organised by the Municipal Agency, 70 Victoria Street, London, SW1. Tel. VICtoria 9132.

Practical Application of Co-partnership in Industry.—Fri., 10 July, to Sun., 12 July, at St. Hugh's College, Oxford. Organised by the Industrial Co-partnership Association, 36 Victoria Street, London, SW1. Tel. ABBey 3342.

***Fluorine Chemistry, Symposium on.**—Tues., 14 July, to Fri., 17 July, at The University, Birmingham. Organised by the Chemical Society, Burlington House, Piccadilly, London, W1. Tel. REGent 0675. (Alteration of opening date.)

Shaft Sinking and Tunnelling, Symposium.—Wed., 15 July, to Fri., 17 July, at Olympia, London, W14. Organised by the Institution of Mining Engineers, 3 Grosvenor Crescent, Westminster, London, SW1. Tel. BELgravia 3691.

***High Energy Physics, International Conference on.**—Wed., 15 July, to Sat., 25 July, in Moscow. Organised by the Academy of Sciences, 14 B. Kaluzhskaya, Moscow.

***Crystal Imperfections and the Chemical Reactivity of Solids, General Discussion on.**—Wed., 2 Sept., to Fri., 4 Sept., at Queen's University, Kingston, Ont. Apply to Dr. J. A. Morrison, Division of Pure Chemistry, National Research Council, Ottawa 2, Canada; or to the Faraday Society, 6 Gray's Inn Square, London, WC1. Tel. CHAncery 8101.

British Association Meeting.—Wed., 2 Sept., to Wed., 9 Sept., at York. Apply to the secretary, British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, WC2. Tel. TRAfalgar 5733.

***Association of Public Lighting Engineers, Annual Conference.**—Tues., 15 Sept., to Fri., 18 Sept., at the Music Hall, Aberdeen. Includes an exhibition of street-lighting equipment and an outdoor display of lamp columns and mobile equipment. Organised by the Association of Public Lighting Engineers, 76 Victoria Street, SW1. Tel. VICtoria 3655.

***Industrial Designers, Conference of.**—Wed., 16 Sept., to Fri., 18 Sept., in Stockholm. Organised by the International Council of Societies of Industrial Designs (ICSID), Stockholm, Sweden.

***250th Anniversary of the Successful Use of Coke in Iron Making.**—Wed., 23 Sept., to Fri., 25 Sept., at The University, Birmingham, and at Coalbrookdale, Shropshire. Apply to the Iron and Steel Institute, 4 Grosvenor Gardens, London, SW1. Tel. SLOane 0061.

SCIENTIFIC RESEARCH

***Scientific Research Exhibition, International.**—Sat., 3 Oct., to Sat., 10 Oct., at Olympia, London, W14. To cover four main themes: Materials, Transport and Communications, Power and Industry, and Health and Food. Organised by International Scientific and Research Exhibitions Ltd., 34-35 Norfolk Street, London, WC2. Tel. COVent Garden 1411. (Additional information.)

***National Electronics Conference.**—Mon., 12 Oct., to Wed., 14 Oct., at the Hotel Sherman, Chicago: Offices: 228 N. la Salle Street, Chicago, Ill., USA. (Alteration of office address.)

Automation Congress and Exposition, Fifth International; and Second Military Automation Show.—Mon., 16 Nov., to Fri., 20 Nov., at the New York Trade Show Building, New York. Organised by Richard Rimbach Associates, 845 Ridge Avenue, Pittsburgh 12, Pa., USA.

Building Exhibition, 28th.—Wed., 18 Nov., to Wed., 2 Dec., at Olympia, London, W14. Offices: 11 Manchester Square, London, W1. Tel. HUNter 1951.

Influence of Plastics in Building, Conference.—Thurs. and Fri., 19 and 20 Nov., at the Royal Institute of British Architects, Portland Place, London, W1. Organised by the Plastics Institute, 6 Mandeville Place, London, W1. Tel. WELbeck 5439.

***Supervisors in Industry, Residential Course for.**—Sat., 5 Dec., to Sat., 12 Dec., at Madingley Hall, Cambridge. Apply to Mr. F. V. H. Ramsbottom, Board of Extra-Mural Studies, University of Cambridge, Stuart House, Cambridge. Tel. Cambridge 56275.

***Boat Show, Sixth National.**—Wed., 30 Dec., to Sat., 9 Jan, 1960, at Earl's Court, London, SW5. Organised by the Ship and Boat Builders' National Federation, 23 Knightsbridge, London, SW1. Tel. BELgravia 6402. (Additional information.)

COMMERCIAL REFRIGERATION

***Industrial and Commercial Refrigeration Exhibition, First.**—Mon., 15 Feb., to Wed., 17 Feb., 1960, at the Old Hall of the Royal Horticultural Society, Vincent Square, London, SW1. Sponsored by *World Refrigeration*. Organiser: Mr. Patrick Smyth, 1 Crane Court, Fleet Street, London, EC4.

***International Mineral Processing Congress.**—Wed., 6 April, to Sat., 9 April, 1960, at the Church House, Westminster, London, SW1. Organised by the Institution of Mining and Metallurgy, 44 Portland Place, London, W1. Tel. LANgham 3802.

***ASTE Tool Show.**—Thurs., 21 April, to Thurs., 28 April, 1960, at the Artillery Armory, Detroit. Organised by the American Society of Tool Engineers, 10700 Puritan Avenue, Detroit 38, Mich., USA.

***Instruments, Electronics and Automation, International Exhibition.**—Mon., 23 May, to Sat., 28 May, 1960, at Olympia, London, W14. Organised by Industrial Exhibitions Ltd., 9 Argyll Street, London, W1. Tel. GERrard 1622.

***Royal Society's Tercentenary Celebrations.**—Mon., 18 July, to Tues., 26 July, 1960, in London. Offices of the Society: Burlington House, Piccadilly, London, W1. Tel. REGent 3335.

***Photogrammetry, Ninth International Congress on.**—Mon., 5 Sept., to Sat., 17 Sept., 1960, in London, under auspices of the International Society for Photogrammetry. Congress director: Colonel J. B. P. Angwin, 18 Cavendish Square, London, W1. Tel. LANgham 1626.

On the Shelf

By Frank H. Smith

I notice an increasing tendency for the publication of snooty journals called "Acta." The word Acta is usually followed by some word denoting a branch of science with "ica" stuck on the end of it. A specimen before me is *Acta Polytechnica Scandinavica* and then, as a sort of anti-climax, Electrical Engineering Series. These are published for the Scandinavian Council for Applied Research and, as well as the series quoted, there are chemistry including metallurgy; civil engineering and building construction; mathematics and computing machinery; mechanical engineering; physics including nucleonics. One can almost hear a humble little journal sulkily saying "I want to be an acta." The address, by the way, is Acta Polytechnica Scandinavica Publishing Office, Box 5073, Stockholm 5.

In case anybody wants to study cryogenics, there is, in the April number of *ARS Journal* (American Rocket Society, 500 Fifth Avenue, New York 36) an article "Recent Advances in Cryogenic Engineering" with 56 references.

There is very little, I would have imagined, in the products of the Morgan Crucible Company Limited of Battersea that would lend itself to eye-catching publicity, but that company is a most energetic disher-out of leaflets, booklets and "latest applications of our products" and their latest booklet, on Morganite carbon brushes, is a good example of what can be done with unpromising publicity material. Very glossy and colourful, one suspects the hand of an industrial designer in its layout.

It is rather awkward to mention *The Intensity of Infra red Absorption Bands* (a bibliography compiled by R. G. Gillis) because it is one of those funny unpublished things coming from a Government department and I do not quite know how one stands for free copies. Ah well—you can but try Chief Superintendent, Defence Standards Laboratories, Box 50, P.O., Ascot Vale, W2, Victoria, Australia. It is their Technical Memorandum No. 2 and contains 134 references, each with a short abstract.

Routledge and Kegan Paul Limited (68-74 Carter Lane, London, EC4) have published their classified catalogue of publications (and if that sounds a bit pompous, that's what they call it) which they will no doubt be pleased to send you. As it is 81 pages I would suggest a token payment of sixpence postage—they can always send it back if they are out of stock.

The Royal Institution of Great Britain (not generally known by that last bit—it usually stops short at Institution) is a rather august body and I do not quite know how you stand (supposing you are interested) with regard to getting a copy of the paper "Scientific Books of the 18th Century and the Emergence of Modern Science" which was delivered to the Library Circle by H. D. Anthony. Try a card to the librarian, at Albemarle Street, London, W1.

The Addison Wesley Company (10-15 Chitty Street, London W1) have issued their 1959 catalogue of scientific and engineering books. An interesting feature is the "centre spread" which tabulates the level of intelligence needed for each book in three classes—mathematics, physics and engineering sciences.

A neat little booklet from G.B. Film Library (1 Aintree Road, Perivale, Greenford) is entitled "Sponsored films from commerce and industry" and the contents cover 19 subjects. The borrower pays postage and insurance and that's all.

In a press handout on behalf of Short Brothers and Harland of Belfast, who have recently made the last of 2,800 weather sorties on behalf of the Air Ministry, a word is used that you may not have come across before. It is "thum"—used adjectivally—and it means temperature and humidity of the upper air masses. Just in case you collect these things.

FLOW LINES CONVERGE

Fundamentals of Gas Dynamics. Vol. III: High Speed Aerodynamics and Jet Propulsion. Edited by HOWARD W. EMMONS. *Princeton University Press, USA;* and *Oxford University Press, Amen House, Warwick Square, London, EC4* (140*s*)

Another majestic volume has now joined the Princeton series. Like its fellows it is a collective work by a panel of illustrious authors, marshalled in the early stages by Crocco and later by Emmons, both of whom also contribute sections to the book. No editor, however distinguished, would have the time or presumption to meddle with such authoritative contributions. The result is that this book has the weakness, characteristic of the series as a whole, that there is considerable duplication and some dissension, both within the book and the series. Some of the volumes have been ill-advised ventures because of the motley collections of topics embraced. In such cases more specialised texts are really more useful. But this particular volume was well worth producing because gas dynamics is inherently a homogeneous subject suitable for treatment in a single volume.

A word on the sense given to the term "gas dynamics" by the compilers of this volume is perhaps necessary. It appears to mean that part of compressible fluid mechanics in which the field of flow is extremely simple geometrically, indeed usually one-dimensional or approximately so. Incidentally, some of the book's most interesting sections are those which explore the actual two or three-dimensional nature of flows commonly treated as one-dimensional. The dynamical aspects of combustion are regarded as falling within the scope of gas dynamics. The major departure from this interpretation of gas dynamics occurs in the introductory section by Tsien on basic compressible flow theory and in the final section by Schaaf and Chambré on rarefied gas flow, where motions past three-dimensional shapes are treated. In fact this concluding section is the "odd man out" and its inclusion in this rather than other volumes of the series is somewhat arbitrary.

It is difficult for an individual to assess the value of a large book on a large subject. In justice a panel of authors demands a panel of reviewers. Nevertheless, some clear points emerge. If, for instance, one views the book from a hypersonic standpoint, it is rather disappointing. The emphasis is still towards perfect gas theory and real gas effects are not prominent, although Crocco gives useful consideration to air at hypersonic temperatures. Tsien even gives the misleading impression that real gas effects are small and of the order of van der Waals corrections, whereas in dissociating and ionising situations they are enormous. The fact that departures from equilibrium in such situations can be very serious is not sufficiently stressed. The kinetics of rate processes is only studied in detail in connection with condensation, combustion and other exothermic waves, although Kantrowitz deals briefly with heat capacity lag in his section on unsteady flows. There appears to be no treatment of such problems as reactive gas flow in the nozzles of rockets or hypersonic wind tunnels. Ionisation and the rapidly growing field of magnetogasdynamics is mentioned only in passing in the brief but useful concluding remarks in the section on shocks by Hayes.

Probably the most widely interesting section is that by Crocco on one-dimensional steady gas dynamics. Despite the abundance of literature on this topic, this excellent restatement is greatly to be welcomed. It begins with a critical appraisal of the one-dimensional approximation that is particularly valuable. There are, of course, detail faults. One deplores the use of the expression "polytropic gas" to mean a perfect gas with constant specific heats. The erroneous statement that $a^2 = \gamma RT$ even when R varies, occurring in the original Shapiro-Hawthorne treatment, is regrettably perpetuated.

One could single out many other valuable features of the book, such as Hayes' comparison of the continuum and kinetic theory approaches to the shock structure problem. The section on combustion is an impressive collective effort. It begins with a survey by von Kármán, continues with the theory of flame fronts by Emmons, and concludes with an extensive study of detonations by Taylor and Tankin. There are also sections by Plachek and Seeger on shock interactions and by Stever on condensation phenomena.

As its title implies, the book does not attempt to carry the topics to the stage of application to external aerodynamics or propulsion. The reader must seek elsewhere to see the matter put into an engineering context. The standard of reproduction is high, but the index is sketchy. Though too formidable for the uninitiated or for the average student, the book possesses the authority and uniqueness which make it worth acquiring by the specialist. After all, not many American textbooks begin with a major contribution from Peking!

J. A. SHERCLIFF.

CONTROL DATA INCREMENTS

Handbook of Automation, Computation and Control. Volume 1: Control Fundamentals. Edited by EUGENE M. GRABBE, SIMON RAMO and DEAN E. WOOLDRIDGE. *John Wiley and Sons Incorporated, 440 Fourth Avenue, New York 16, NY, USA;* and *Chapman and Hall Limited, 37 Essex Street, London, WC2.* (136*s*)

Introduction to the Design of Servomechanisms. By JOHN L. BOWER and PETER M. SCHULTHEISS. *John Wiley and Sons Incorporated, 440 Fourth Avenue, New York 16, NY, USA;* and *Chapman and Hall Ltd., 37 Essex Street, WC2.* (104*s*)

Position Control of Massive Objects. By A. TUSTIN and others Part C, Supplement No. 1, of *The proceedings of the Institution of Electrical Engineers, Savoy Place, London, WC2.* (8*s* 6*d* *members*, 15*s* *non-members*)

Les Notions de Base. By LOUIS COUFFIGNAL. *Gauthier-Villars, 55 Quai des Grands-Augustins, Paris* (6*e*), *France.* (600 *F*)

These four publications, representing cardinally opposed contributions to the literature of control and information theory, are respectively: a broad work of reference; a detailed description of design techniques for immediate use; a work of scholarship and research, and a monograph dealing with the epistemology of cybernetics. To a greater or less extent, all new writings on these subjects are based on the work of such pioneers as Boole, Nyquist, Shannon or Wiener. In view of the very high cost per pound weight of technical literature, it is only reasonable to consider whether a new book contains more than a marginal quantity of fresh material, or alternatively presents the old in a more striking manner.

The editors of a *Handbook of Automation, Computation and Control* have set out to encompass in three large volumes enough mathematics and other technical matter of all kinds, copiously referenced to provide a major part of the theoretical background for any worker in this field for some years to come. This first volume, "Control Fundamentals," demonstrates how difficult a task has been attempted. Surprisingly it falls farthest from its mark in the long final section on "feedback control." This is a

compilation of rather disconnected chapters dealing with insufficiently distinct parts of the subject; it is overlavishly supplied with tables of mathematical equivalents and tabular comparisons, many lifted bodily from published papers without sufficient regard for consistency of intellectual level. Particularly irritating is the table of feedback control definitions—which is both imprecise and badly proof-read—while the table of " error correctors " and their important parameters is misleading, lacking as it does any reference to the rates at which power output can be changed.

These inadequacies are the more disappointing in view of the earlier, excellent sections on " general mathematics " and " numerical analysis." The former is a remarkable survey of the major mathematical phenomena in the relevant disciplines. Due respect is paid to rigour, in that basic concepts and theorems are rigorously introduced, although only an indication is given of methods of proof. For example, the opening chapter on " sets and relations " provides a foundation both for the development of matrix theory and for Boolean algebra; matrices are actually introduced from a consideration of vector spaces and linear transforms. " Numerical analysis," a section of 90 pages, gives a critical account of many computational methods for handling differential equations and matrix algebra; some indication is given of their relative merits when used with digital computers. The references here are particularly comprehensive, and it is only a pity that the new methods of Professor Kopal of Manchester University for numerical integration should have appeared just too late for inclusion.

In the section devoted to " information theory," sources of information and channel capacity are discussed cogently and in logical sequence for both discrete and continuous cases. Smoothing, prediction and optimum filtering are less efficiently handled, primarily owing to over-condensation, while the space devoted to data transmission could more usefully have served for an extended treatment of the former topics, since the approach is disjointed and lacks generality. A highly condensed section on " operations research " is also included which introduces very briefly the topics which have come to be associated under this heading.

It is to be hoped that the further two volumes —" Computers and Data Processing," and " Systems and Components "—will follow the example set in the more theoretical chapters of Volume I, but perhaps this is more than can reasonably be expected, since mathematical techniques have a more enduring validity than the physical problems and solutions to which they are applied.

Introduction to the Design of Servomechanisms is a much less ambitious work, intended as a textbook describing in detail the design methods applicable to various control problems. A very adequate theoretical introduction pays particular attention to the intellectual difficulties of functional transformations; this leads logically to a consideration of the relationship between amplitude and phase characteristics in the minimum phase condition. The following chapter introduces the concept of stability with a definition which, while not completely rigorous, could well supplant that given in the first work under review. The Nyquist Criterion, Boole Diagram and Root Locus technique receive a chapter apiece, while consideration is also given at some length to performance criteria in both noise-free and noisy input conditions.

In a sense, linear control theory is only a special case of non-linear theory, so that one must not expect too much from a single chapter on " non-linearities in servo design." Although several techniques are briefly described, there is no explicit attack on the problems of backlash and hysteresis, the commonest forms of non-linearity after saturation. Time-varying systems are mentioned, but a discussion of the " z-transform " must be sought elsewhere.

The authors have largely succeeded in their attempt to produce a self-contained textbook; references to other works are very few indeed. A more comprehensive index would improve the next edition, but to offset this deficiency, the assiduous designer can sharpen his wits on the numerous problems appended to each chapter.

In the *Position Control of Massive Objects*, Professor Tustin and his colleagues discuss a yet more limited area of control theory, where power amplification is required from the electrical machinery of a system, in addition to any electronic amplifiers. Two very useful concepts are employed, " phase utilisation "—the way in which allowable phase lag is distributed among system components—and " r "—the parameter obtained by dividing the time constant of a system component by its power gain. As in the previous book, particular emphasis is given to consideration of component variability, leading to the need for minor-loop stabilisation. One important conclusion is that rotary amplifiers in general use are not optimally designed in the light of the theory expounded.

Since practical application of the design principles discussed does not follow without further elaboration, this paper is clearly directed at those engineers with a continuing responsibility for the development of this type of system who can influence the design of the major electrical components; to them it will be of considerable value.

Unlike all these publications, *Les Notions de Base* is concerned entirely with the terminology and epistemology of control theory. Dr. Couffignal argues in lucid Cartesian prose that cybernetics is an art concerned with the underlying patterns which distinct systems and organisms have in common. By this art, actions can be specified to bring about desired results. It is not necessary to know what practical use may be made of the conclusions in this kind of discourse to be certain that it serves as a valuable corrective to the loose definitions and worse prose with which too many technical books are written.

I. W. MERRY

THE RIGHT WAY WITH MATERIALS

1958 Book of ASTM Standards including Tentatives. Part 1: Ferrous Metals (Specifications); Part 2: Non-Ferrous Metals (Specifications), Electronic Materials; Part 3: Methods of Testing Metals (Except Chemical Analysis); Part 4: Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils; Part 7: Petroleum Products, Lubricants, Tank Measurements, Engine Tests; Part 9: Plastics, Electrical Insulation, Rubber, Carbon Black; Part 10: Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes. *American Society for Testing Materials, 1916 Race Street, Philadelphia, 3, Pa., USA.* (Obtainable from the British Standards Institution: Parts 1, 4 and 7, £5 14*s* each; Parts 2, 3 and 10, £4 15*s* each; and Part 9, £6 13*s*.)

The avowed purpose of the American Society of Testing Materials is " the promotion of knowledge of the materials of engineering, and the standardisation of specifications and the methods of testing " and this " book " (of which parts 1, 2, 3, 4, 7, 9 and 10 have so far been received) are the triennial memorial to this avowal. Supplements are issued in the intervening years.

It is inevitable that some people should try to draw comparisons between the ASTM products and those of our own British Standards Insitution but anybody familiar with similar bodies here and in the States knows that no such comparisons can ever be drawn. Outlooks are different, methods of administration are different and, above all, financial considerations are different. No American organisation appears ever to have to work on a shoestring or even something a little stronger, like a ship's cable. The money is there.

In view of the fact that these standards are another case of " those who use them know all about them and those who don't won't want to " it will suffice if the subject-matter of each volume is indicated so that the former class will know which one to borrow.

Part 1 deals with ferrous metals (specifications) and runs to 1,589 pages, the last 24 of which are index. Part 2 is non-ferrous metals (specifications) and electronic materials: 1,354 pages, 23 of index. It is perhaps surprising to see tables of hardness conversion numbers for steel in this volume. Part 3 is methods of testing metals (except chemical analysis) with 962 pages, including nine of index. With part 4 we break away from metals and embark on cement, concrete, mortars, road materials, waterproofing and soils. With such a multiplicity of subjects it is curious that this volume still has less pages than part 1: a mere 1,422 with 29 of index (it wins there). Fluids flow into part 7 on petroleum products, lubricants, tank measurements, engine tests: 1,485 pages, 22 of them index. Part 9 is the largest so far: 2,018 pages devoted to plastics, electrical insulation, rubber and carbon black, 39 pages of index. Part 10 includes the schoolboy's aversion. It is textiles, soap, water, atmospheric analysis and wax polishes: 1,493 pages, the last 26 of which are index.

The parts not so far received include part 5, which is devoted to masonry products, ceramics, thermal insulation, acoustical materials, sandwich and building constructions, and fire tests. Part 6 considers wood, paper, adhesives, shipping containers, cellulose and leather; and part 8 deals with paint, naval stores, aromatic hydrocarbons, coal and coke, gaseous fuels and engine antifreezes.

As will be seen, any part can be taken for one of those " odd man out " questions beloved of school examiners and one wonders if the ASTM offers prizes to anybody who can name a material they have left out. A few figures culled from a preface may be of interest. Committees now have more than 100 research projects under way. There are some 80 of these committees. About 2,450 standard specifications and methods of test have been formulated. From 70 in 1898, ASTM now numbers over 9,500 individuals and organisations. Strangely enough, not even an industrial diamond is given away with these volumes, published 60 years later.

F. H. SMITH

The Reviewers

Dr. J. A. Shercliff is a lecturer in the department of engineering, University of Cambridge, and is particularly concerned with fluid dynamics, thermodynamics and magneto-hydrodynamics. He is a Ph.D., an M.A. and an S.M.

Mr. I. W. Merry, B.Sc.(Eng.), A.M.I.E.E., has been active for several years in the digital computer field on both sides of the Atlantic, and was responsible for the design of the main store in the computer Pegasus. He recently joined Solartron Electronic Business Machines Limited, to continue work on data handling, particularly in the development of novel input devices.

Mr. Frank H. Smith writes: "Those of you who read the short autobiographical note on page 650, 15 May, will realise that one who was brought up (as I was) on a diet of French polish and French mustard would never make such errors as 'entrepeneur' and 'maladriot'. I think somebody gets a little confused with his r's somewhere between my typewriter and the finished product. Silly r's."

LUBRICANTS UNDER RADIATION*

Nuclear Power Stations Present New Problems to the Oil Industry

By C. G. WILLIAMS, D.Sc., M.I.Mech.E., F.R.Ae.S., F.Inst.Pet.
Director and General Manager, Shell Research Limited

During the next ten years it is expected that nuclear power stations will provide a total electrical generating capacity of at least 10,000 MW in the United Kingdom and Western Europe. Futhermore, the use of nuclear energy in the marine field will also receive increasing attention in attempts to utilise this new source of power at an economic level. These developments present new problems to the oil industry, in particular novel lubrication conditions not encountered previously. While many of the requirements of a nuclear power station are covered by conventional lubricants (such as turbine oils for the generating equipment), other requirements (see Fig. 1) call for lubricants having special properties. For example, the CO_2-circulating fans must be lubricated with an oil which has low vapour pressure so that little oil will pass into the gas stream and contaminate the reactor. Similarly the oil shall have low solubility for CO_2 so that no hold up of CO_2 (which may be slightly active) in the gas separation equipment shall occur.

A more rigorous requirement is that for certain applications the lubricant must be reistant to β, γ and neutron radiation. Two applications for such lubricants in a natural-uranium graphite-moderated CO_2-cooled reactor can be summarised as follows:—

(i) *Lubrication of the Control Rod Mechanism.*—The release of energy in the reactor must be controlled and a steady supply of neutrons just sufficient to maintain the chain of reactions is required. The level of activity is normally controlled by boron-steel rods which readily absorb neutrons; these rods can be pushed in and out of the reactor as required. The control-rod operating mechanism is located on the reactor outside the biological shield, and ball, roller and plain bearings together with gears require lubrication at temperatures between 100° C and 200° C. In addition, the lubricant will be exposed to a small amount of radiation, principally in the form of gamma rays, and will be expected to withstand these operating conditions for a number of years.

(ii) *Lubrication of the Charging Mechanisms.*—These mechanisms are used for charging and discharging the uranium fuel rods in the reactor. Some parts of the mechanisms are inside the reactor and are subject to intense radiation. Under these conditions, sliding surfaces require lubrication at temperatures between 400° and 450° C. The high operating temperatures preclude the use of hydrocarbon materials as lubricants, and dry lubricants such as molybdenum disulphide and Sulfinuz treatments are under consideration for this application.

Other parts of the charging mechanisms, however, are outside the reactor, and here ball, roller and plain bearings require lubrication at temperatures up to 200° C in the presence of neutrons and associated radiation from the reactor, together with intense gamma rays from used fuel elements while these are in the machine. Although the temperature is lower in this part of the mechanism, the radiation flux is still significant.

These applications emphasise the need for lubricants which will perform satisfactorily not only at elevated temperatures but also in the presence of nuclear radiations. This latter requirement opens up an entirely new aspect in

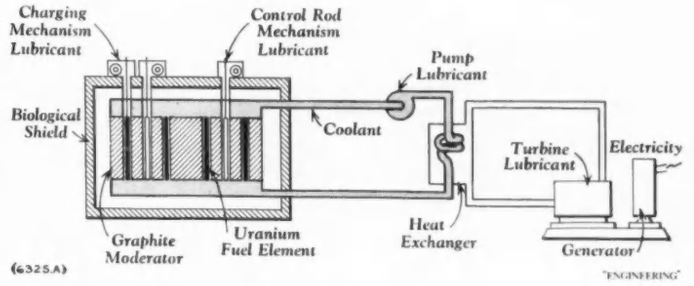


Fig. 1 Simplified diagram of a nuclear power station showing principal points where lubrication is required.

* "Lubricants in the Nuclear Age". A paper read to a joint meeting of sections A and G of the British Association in Glasgow on 2 Sept. 1958.

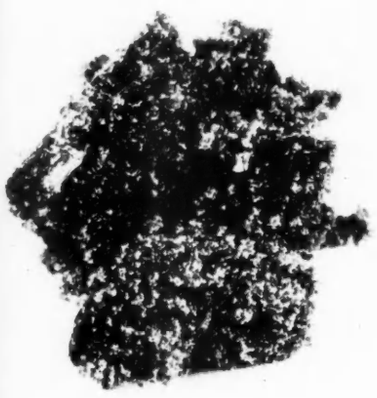


Fig. 2 Illustration of a hydrocarbon oil which has solidified during irradiation with neutrons.

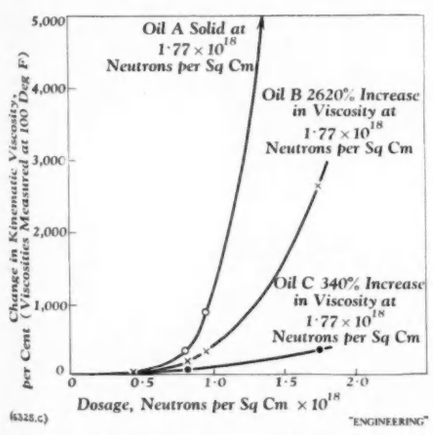
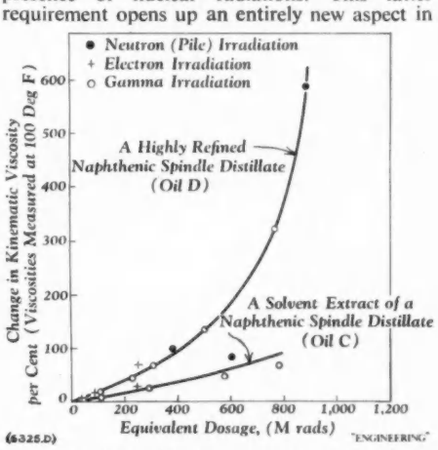

Oil A Solid at 1·77 × 10^18 Neutrons per Sq Cm
Oil B 2620% Increase in Viscosity at 1·77 × 10^18 Neutrons per Sq Cm
Oil C 340% Increase in Viscosity at 1·77 × 10^18 Neutrons per Sq Cm
Change in Kinematic Viscosity, per Cent (Viscosities Measured at 100 Deg F)
Dosage, Neutrons per Sq Cm × 10^18
(6325.C)
"ENGINEERING"

Fig. 3 Relationship between neutron dosage and per cent increase in viscosity (cS at 100° F).


Neutron (Pile) Irradiation
Electron Irradiation
Gamma Irradiation
A Highly Refined Naphthenic Spindle Distillate (Oil D)
A Solvent Extract of a Naphthenic Spindle Distillate (Oil C)
Change in Kinematic Viscosity per Cent (Viscosities Measured at 100 Deg F)
Equivalent Dosage, (M rads)
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"ENGINEERING"

Fig. 4 Relationship between percentage change in kinematic viscosity at 100° F and dosage for neutron, gamma and β irradiated oils.

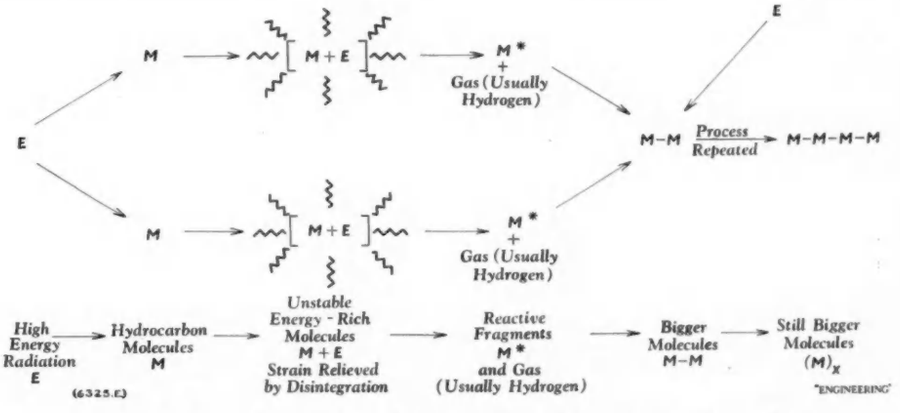


Fig. 5 Diagram of the degradation of hydrocarbon molecules when exposed to radiation.

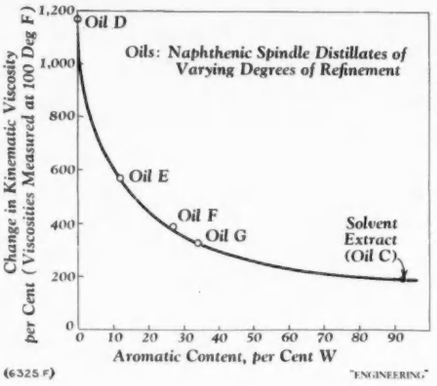


Fig. 6 (left) Relationship between percentage increase in viscosity (at a neutron dosage of 1·27 × 10^{18} neutrons per sq. cm) and aromatic content.

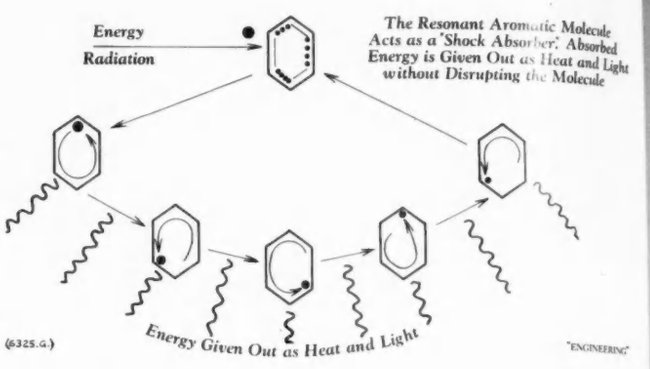

Energy Radiation
The Resonant Aromatic Molecule Acts as a 'Shock Absorber.' Absorbed Energy is Given Out as Heat and Light without Disrupting the Molecule
Energy Given Out as Heat and Light
(6325 G)
"ENGINEERING"

Fig. 7 (right) Effect of aromatic compounds on radiation stability.

the field of lubrication, and some of the investigations designed to solve this problem will now be described.

Since 1953 the problem of developing lubricants capable of withstanding the deleterious effects of nuclear radiation has been actively pursued at Thornton Research Centre. In collaboration with the Atomic Energy Research Establishment a wide range of materials has been irradiated in the BEPO pile at Harwell, and this work has been consolidated using a 250 curie cobalt-60 source of gamma rays. In addition, irradiations have been carried out using electrons from a 4MeV linear accelerator at Metropolitan-Vickers Electrical Company Limited, Manchester. The salient features from these investigations are as follows:—

(i) *Hydrocarbon Oils.*—All the hydrocarbon oils examined were found to increase in viscosity to varying extents and eventually, in some cases, became solid at the higher pile dosages (about 1·8 × 10^{18} neutrons per sq. cm). These "solid oils," illustrated in Fig. 2, had soft, jelly-like consistencies with high melting points in excess of 220° C; they were incompletely soluble in various common solvents such as benzene, ethanol and ether. Other oils, however, remained fluid at these high neutron dosages as shown in Fig. 3 for oils A, B and C. Oil A, a high-viscosity bright stock, became solid while oils B and C showed lower degrees of polymerisation, the smallest change being that for the highly aromatic solvent extract, oil C.

The cross-linking (polymerisation) of the oil occurs irrespective of the type of radiation used. In fact, if the results from separate experiments with neutrons, electrons and gamma rays are reduced to a common energy-absorption level, then a satisfactory correlation (illustrated in Fig. 4) is found for the three types of radiation in the effects they produce. Similar processes, therefore, are taking place under the three conditions. These processes (Fig. 5) include:—

(*a*) energy transfer from the radiation to the hydrocarbon molecule;

(*b*) dissociation of this energy-rich molecule into a highly reactive fragment accompanied by the evolution of gas (mainly hydrogen); and

(*c*) the combination of active fragments to give compounds of higher molecular weight and viscosity.

A major factor which determines the resistance of an oil to the effects of nuclear radiation is the presence of aromatic compounds. This is shown in Fig. 6, which gives the results for the pile irradiation of a series of hydrocarbon oils (D to G) prepared from the same crude but of differing aromatic content. The results clearly indicate that there is a significant decrease in radiation damage with increasing aromatic content. It is probable that the aromatic compounds are acting as "energy sinks" (Fig. 7) and are able to dissipate absorbed energy without undergoing drastic changes leading to cross-linking and viscosity increases.

After irradiation with neutrons in the BEPO pile, many oils were found to be radioactive, the activity increasing with increasing sulphur content of the oil (see Table). This was traced to the presence of a radioisotope of phosphorus, P-32, which emits electrons and has a half-life of about 14 days. The isotope is formed from sulphur S-32 (present in most petroleum lubricants) by capture of a neutron followed by the ejection of a proton. After pile irradiation it is therefore necessary to allow oils to "cool" to a low level of activity before examination in the laboratory. Unlike neutrons, however, gamma rays do not give rise to this induced radioactivity, and gamma-irradiated samples can be safely handled immediately after test.

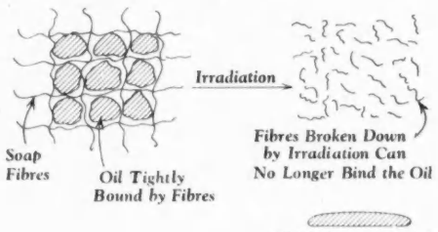

Irradiation
Soap Fibres
Oil Tightly Bound by Fibres
Fibres Broken Down by Irradiation Can No Longer Bind the Oil
Oil No Longer Bound by Degraded Fibres
Conventional Soap Gelled Greases Break Down when Irradiated Owing to Destruction of the Soap Fibres
"ENGINEERING"

Fig. 8 Breakdown of greases during irradiation.

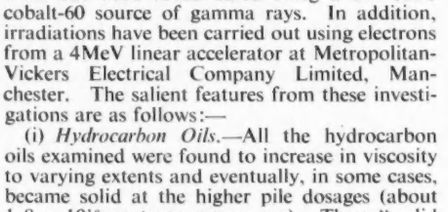


Fig. 9 Comparison of stabilities to irradiation of hydrocarbon mineral oils and commercially available silicone fluids.

Effect of Sulphur Content on Radioactivity of Oils after Pile Irradiation.

Sulphur content per cent W	Count (above background) p.p.s. per sq. cm.
0·002	1
0·2	17
0·55	70
0·65	160
4·05	550*

Instrument: Geiger Müller EHM 2 thin-window counter. Above measurements made approximately 2 months after removal of oils from the pile.
Dosage: 1·27 × 10^{18} neutrons per sq. cm.
* Dosage of 0·83 × 10^{18} neutrons per sq. cm.

(ii) *Greases.*—In general, a conventional grease consists of a hydrocarbon oil which has been gelled with a sodium, lithium or calcium soap. Such greases have been found to have poor radiation stability, becoming liquid at relatively low dosages. These changes are virtually independent of the type of base oils used in the preparation of the grease, and are indicative of a significant breakdown in the structure of the gelling agent, as shown in Fig. 8. One way to achieve a radiation stable grease is to use an inorganic gelling agent. Greases based on hydrocarbon oil have been shown to be stable to irradiation dosages as high as those which the base oil itself will withstand, and offer considerable promise in applications where grease, as distinct from oil, lubrication is desirable.

(iii) *Synthetic Fluids.*—The phenomenon of polymerisation or cross-linking under the influence of nuclear radiation is not peculiar to hydrocarbon oils but extends also to many synthetic materials such as the well-known silicone fluids. In view of their high thermal stability and good viscosity/temperature characteristics, various commercially-available silicones of differing viscosity and aromatic content have been irradiated. As expected from experience with hydrocarbon oils, the non-aromatic polydimethyl siloxanes were the least stable, while those containing aromatic groupings were more satisfactory. Fig. 9 shows a comparison between the radiation stabilities of the commercially available silicones and a wide range of hydrocarbon oils; it is concluded that, as a class, hydrocarbon mineral oils are relatively stable materials under these severe conditions. Other synthetic fluids have also been examined. One of these, di (2-ethyl hexyl) sebacate which has been of interest in the past few years as a component of synthetic aviation gas turbine lubricants, was transformed into a solid and appears unpromising as a radiation-resistant fluid.

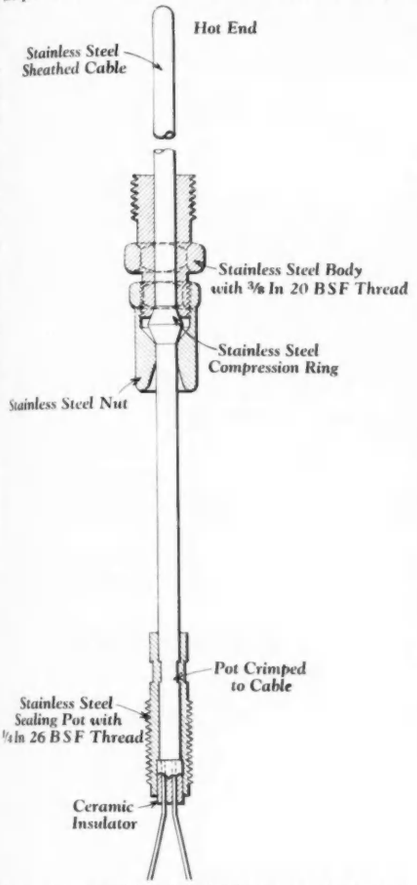
CONCLUDING REMARKS

What of the future? Temperatures will be pushed higher and reactor neutron fluxes will increase. This means that the demand made on the lubricants will also go up. In some reactors it is suggested that the reactor coolant will be circulated to the turbine directly. If this coolant is radio-active, then the turbine lubricant must be stable to the radiation.

In the time available it has been possible only to "highlight" certain features of this new and fascinating field. Radiation-resistant lubricants are already available to meet the known requirements of nuclear power stations at present under construction. However, as experience is gained and progress is made in the design, construction and use of nuclear power equipment, new lubrication problems may well continue to arise. The presence of nuclear radiation adds a complicating factor to the already complicated field of lubrication; the above work, it is believed, will continue to assist in solving some of the problems and will give a better understanding of lubrication in the nuclear age of the future.

MINERAL INSULATED THERMOCOUPLES

Experience gained in the manufacture of mineral insulated cables has enabled British Insulated Callender Cables to extend their range of thermocouples to make a flexible instrument of small overall diameter and high tensile strength. The thermoelectric conductors—nickel-chromium for the positive and nickel-aluminium for the negative—are embedded in highly compressed magnesium oxide insulant and then completely encased in a seamless, circular, stainless-steel sheath. When heat is applied to the hot end a small voltage is generated which is proportional to the temperature causing it, and a meter can therefore be calibrated to give a direct temperature reading.


Hot End
Stainless Steel Sheathed Cable
Stainless Steel Body with ⅜in 20 BSF Thread
Stainless Steel Compression Ring
Stainless Steel Nut
Pot Crimped to Cable
Stainless Steel Sealing Pot with ¼in 26 BSF Thread
Ceramic Insulator

The thermocouples are availabe in standard overall diameter sizes of 0·122 in and 0·060 in, but intermediate sizes are also available. Other dimensions and particulars are:—

	0·122 in size	0·060 in size
Radial sheath thickness, in ..	0·012	0·006
Minimum insulation thickness	0·020	0·010
Conductor diameter, in ..	0·020	0·010
Resistance of T_1 conductor, ohms per ft	1·1	4·6
Resistance of T_2 conductor, ohms per ft	0·44	1·85

Minimum insulation resistance 100 megohms per unit.

In the standard hot junction the conductors are welded together, and the sheath is welded over to form a hermetic seal completely insulated from the conductors. This does not increase the overall diameter of the cable or make installation any more difficult. For the first time thermocouples of all sizes down to 0·060 in diameter can be supplied with an insulated junction.

At the other end, the cold end, a seal is fitted to prevent the insulant from absorbing moisture. The seal body is externally threaded to facilitate plain-hole entry into junction boxes and instrument casings where it can be held in place by locknuts. The cold end assembly will operate at temperatures up to 150° C. Alternative arrangements at hot and cold ends can be made on request.

The thermocouples have a rapid thermal response because of their small volume and the high density of the insulant gives excellent heat conductivity. Units are available in long lengths up to 100 yd long and of small overall diameter.

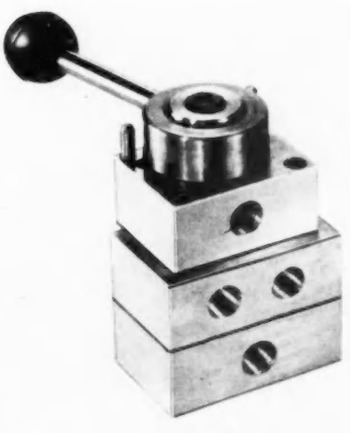
SUPPORTING GOAF DEBRIS

On coalfaces where the waste is totally removed (caved), flushing of the waste, resulting in an overflow of debris towards the face, is often a problem. It creates difficulties in advancing the supports and in travelling on the face itself. The overflow can be eliminated by a series of steel plates suspended at roof level from the goaf (working face) end of a three-legged canopy. The size of each plate varies according to seam conditions and support intervals, but at Kiveton Park Colliery, where they have been under trial, the three-legged units of the Roofmasters are at 5 ft centres, and the shields are 4 ft 3 in long. The working height at the goaf edge is approximately 3 ft, and the shields are 18 in deep.

The shields are fixed to the canopies in the following manner. A steel saddle is fitted over the goaf end of the canopy and fastened by three studs. It is held in place by tension bolts attached to the canopy lifting lugs. A fabricated steel shroud, of approximate channel section and the length of the shield, is welded to the rear of the saddle and strengthened with gussets also welded in position. The shield plate itself is then hung from inside the shroud on chain links. In an early design the shield was simply welded directly on to the saddle; a modification provides a hinge which permits the assembly to move over roof falls between supports, and also allows a certain amount of vertical play which is essential where the roof tends to follow the lowering of the canopy. The shroud prevents any debris interfering with the links. Stops are fitted to prevent pressure from the debris pushing the shield plate too far forward.

AIR VALVE WITH NEOPRENE DIAPHRAGM

A new pattern of air control valve, embodying a diaphragm poppet action which is the subject of a patent application, is being made by Air Automation, 26 Sharrocks Street, Wolverhampton. The sealing is effected by neoprene diaphragms and gaskets and does not rely on close tolerances, on metal to metal seatings, or on O-rings. Maintenance involves only loosening four screws and replacing the neoprene elements. The air flow is isolated from the detents by the diaphragm, which is perforated and closed under compression when the valve is open.

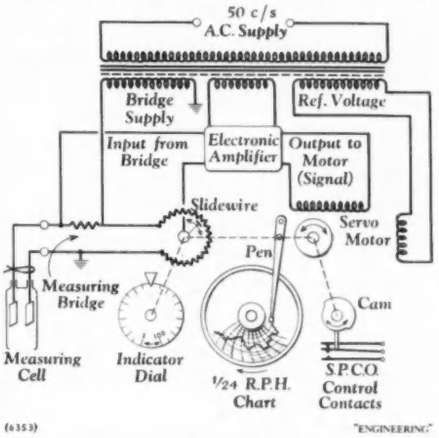


The valves consist of a base block and a head block; a four-way unit as is shown in the illustration. The base blocks are common to the range and the action of the valve can be altered (for example, from roller to hand lever) by only changing the head block. For three-way valves, the head block can be turned 90° or 180° to the base block by undoing the four securing screws and rotating the head. The valve stems and diaphragms are identical for a given size (⅛ in or ¼ in BSP) in both the three-way and four-way units, so that replacements are easy.

MONITORING ELECTROLYTES BY THEIR CONDUCTIVITY

The RIC3 electrolytic conductivity recorder, incorporating automatic control, has been designed for the limited task of measuring, indicating and recording the conductivity of electrolytes. The instrument is made by Electronic Switchgear (London) Limited, Letchworth, Hertfordshire.

The basic instrument is an automatically self-balancing a.c. measuring bridge, which employs as the measuring element a conductivity cell (of patented design) that isolates a specific volume of the electrolyte in which it is immersed. Variations of electrolytic conductivity cause the measuring bridge to become unbalanced; the resulting a.c. potential, which appears at the output of the bridge, is sensitively detected by an electronic amplifier. The output of the amplifier is applied to the "signal" winding of a double-wound induction motor. The phase of the amplified signal is determined by the sign of the conductivity change and the phase relationship between the signal and a fixed reference a.c. potential, continuously applied to the second winding of the motor, determines the direction that the motor must rotate to drive the measuring bridge slidewire to restore the balance.



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The indicating dial and recording pen are mechanically coupled to the slidewire shaft and they indicate and record the conductivity changes as they occur. Rear-of-panel access is provided to the valves and this arrangement simplifies installation and maintenance because the terminal connections are also at the rear of the panel where the service wiring is contained. Presetting of the controls is by finger-tip adjustment on the chart and indicator panel.

Applications include the recording and indication of conductivity of steam condensate and heat exchange media, where continuous purity may be of utmost importance in the effective and safe operation of plant. The instrument will monitor the electrolyte, diverting it to waste in the event of contamination. Efficiency of rinsing can also be supervised. Another use is the control of conductivity in plant used for the purification of brackish water by electrodialysis.

USING DIGITAL COMPUTERS *to* DESIGN ELECTRICAL MACHINES

Better Consideration given to Complex Factors

By D. D. STEPHEN
B.Sc., A.M.I.Mech.E., A.M.I.E.E.
Heavy Plant Division AEI Rugby

The duty of a designer is to determine the dimensions and specification of a machine which will perform a given duty and comply with certain specified limitations. Such limitations depend on the data available, but these, in turn, depend on the measuring devices which exist. Originally electrical machines were only required to generate or to motor, and the outputs were largely a matter for speculation. Quickly, however, comparatively crude rules of design were developed and these enabled reasonable forecasts to be made of the outputs to be obtained, based on the design data.

As more experience, and therefore more data, was accumulated such rules were developed into fairly rigid theories. These theories were of the "lumped value" type, e.g., the machine was said to carry "a flux." Unusual phenomena were often deliberately ignored until accurate means of measurement became available or until serious trouble was encountered, e.g., the realisation of transient effects during machine short-circuits. Thus the knowledge of actual machine behaviour was dependent on the development of accurate measuring devices, the work of analytical investigators, the availability of convenient mathematical methods for dealing with the equations involved, and the availability of people who could appreciate all these factors.

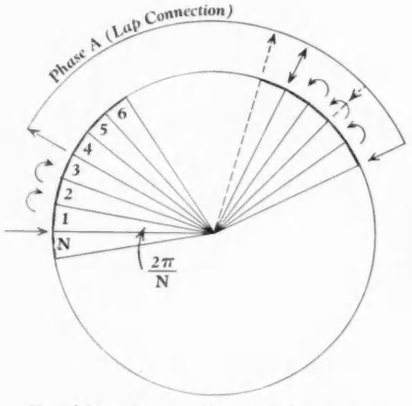
The foremost machine designers were those people who could devise simple and quick methods of representing machine performance, although this led to the use of stereotyped design procedures. These procedures enabled designers to produce economic designs for conventional machines—an essential requirement from the industrial point of view—but because each aspect of machine behaviour had been treated individually, different values for the same parameter of the same machine had often been used to give the satisfactory results in the calculation of different performance characteristics.

This conflict, although acceptable to the skilled designer, who realises that neither of the values is correct in reality, can be most confusing to the young engineer or student and can cause considerable differences between college teaching and industrial practice, in addition to creating difficulties for the student.

In recent years great advances in accurate measuring devices have revealed much lack of knowledge of machine performance and the values used for more detailed specification of machine characteristics. For instance, the early concepts of voltage regulation and of starting torque and current were sufficient to determine machine performance, but limiting values may now be imposed on a large variety of quantities such as transient reactance, synchronising torque, positive and negative damping coefficients, surge impedance and transit time, and many others. To deal with such new features, increasing use has had to be made of mathematical techniques such as operational calculus, matrix and tensor theory, topology, vector analysis and wave theory. Unfortunately these not only involve an increase in the knowledge required by machine designers but also entail the expenditure of more time in calculating the performance of machines. In the past, it has been necessary to reduce the amount of calculation by using theories based on such simplifying assumptions as neglecting saturation and then making allowances for it at a later stage.

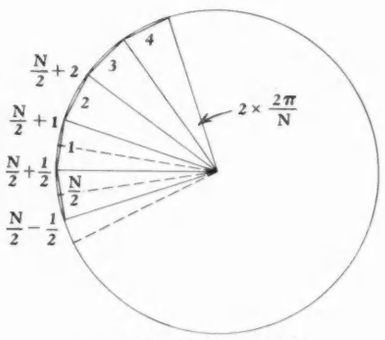
Most designers will admit that more accurate theories are available for all their problems but they all involve more work than the more conventional ones and are justified only in a few instances. Occasionally, however, these theories must be used and so knowledge expands. Their validity can only be checked infrequently and improvement is consequently slow. If the improved methods of calculation could be performed in the same time as the more conventional ones, and by the same staff, then improvement could be very much more rapid. The advent of the digital computer has made this possible. However, designers cannot instantly discard old procedures as reference to past experience would thereby be sacrificed, and the first use to which the digital computer has been put is to carry out standard procedures and so relieve designers of much time-consuming calculation. The designer still specifies the data and inspects the results and, as the computer accuracy is greater than his own, no loss of efficiency results.

Fig. 1 Basis for computer calculation of "fractional slot" winding characteristics.



Dotted Lines Show an Alternative Connection

Actual Space Slot Vectors for N Slots Corresponding to 2-Pole Electrical Slot Vectors



Dotted Lines for N Odd

4-Pole Electrical Slot Vectors (Electrical Slot Angle = Space Slot Angle × No of Pole Pairs)

Phase A First Connection

Slot Connection	Slot No	2-Pole Angle	2-Pole sin	2-Pole cos	4-Pole Angle	4-Pole sin	4-Pole cos		Fundamental Angle	Fundamental sin	Fundamental cos		Harmonics Order n
→ ↺ ↺ ←	1	$\frac{2\pi}{N}$			$\frac{4\pi}{N}$				$p\frac{2\pi}{N}$				$np\frac{2\pi}{N}$
	2												
	3												
Σsin Σcos													
Winding Distribution Factor													

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DIGITAL COMPUTER CHARACTERISTICS

The basic function of a digital computer is to carry out the manipulation of numbers. The sequence and form of such manipulation can be predetermined by giving it appropriate instructions. It can carry out long manipulations quickly and with great accuracy or it can repeat a calculation with a wide range of variables rapidly. One limitation of such a machine is its available storage capacity for numbers or instructions in conjunction with the time required for reading from the store.

The time required for printing out results can also be limiting. A computer is thus quite

suited to do routine calculations normally performed by skilled engineers where the only requirements are knowledge of the correct data, accuracy in the calculation and the ability to see if the results are reasonable. For example, the calculation of the starting current and torque/slip curves from the original design data is laborious but elementary, and a skilled designer can quickly check whether the resultant curves are consistent with the input data without going through the complete calculation. The amount of output data is appreciable in relation to the input data and this is an excellent example of the first use of a computer in relieving the design engineers of the burden of time-consuming calculations.

To use a computer efficiently for machine design problems it is necessary to have full knowledge of computer operation and to be in a position to prepare the best type of programme for the calculations concerned. The actual sequence of calculations performed by a designer using a slide rule or calculating machine is not always the most economic one when using a computer to perform the calculation, and this factor is important when preparing a programme. Thus, a designer would normally avoid the use of matrices of an order greater than 4 by 4, although basically their manipulation is simple. The computer, however, can deal with matrices easily and this fact is of considerable importance as modern machine analysis is based on matrices. Another factor which is convenient when using a computer is the modern trend to the use of per-unit systems in machine analysis as it simplifies programming by making the predetermination of the ranges of values very simple.

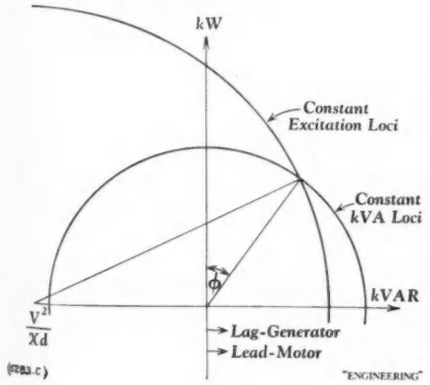
WIDER CHOICE OF DESIGN

It is quite practicable to prepare programmes so that the computer will perform all the design calculations normally performed by a designer and produce the complete performance characteristics of the machine, and by feeding in appropriate data, the characteristics of several alternative designs can be obtained. This process, of course, still requires a skilled designer to determine suitable data to feed into the computer. The designer can thus have a much wider choice of designs from which to select the best.

It is also possible to arrange for the computer to compare the calculated performances of each possible design with the specified requirements and to select the design which matches them most closely.

The range of possible variables in the design of electrical apparatus is very great indeed and it will be a long time, if ever, before a computer can be designed to exhibit all the intuition and experience of a trained designer. At present it is more economic to reduce the vast amount of existing data—such as dimensions of dies and punchings, preferred sizes of copper, forms and types of insulation, numbers of slots (stator and rotor)—by the skill of designers who can quickly select possible combinations which could result in reasonable designs. In this way the input data to the computer can be quite compact and the designer can be used to the best advantage as he can spend much more time determining the significance factors in obtaining specific characteristics of machines.

Fig. 3 Simple circle diagram for synchronous machines.



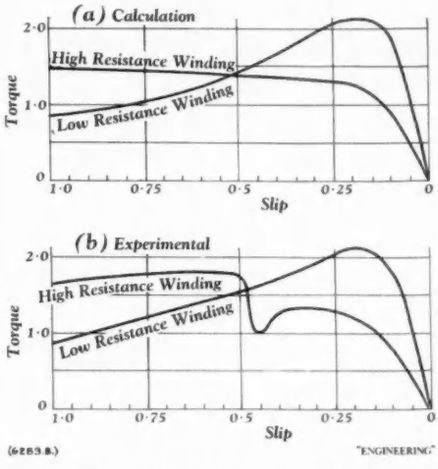


Fig. 2 The starting performance of synchronous motors can be analysed using equivalent circuits. High resistance rotor windings require a complex circuit to represent all the characteristics correctly.

When the apparatus involved possesses only a small number of possible variables—for example, a quantity-produced industrial induction motor with standard punchings and slots in which the winding is the only part which can be adjusted consistent with manufacturing economy—then a computer can conveniently be used to give the best design from a choice of input alternatives. This is particularly so when the specified characteristics are few in number and are always the same, for example, starting torque and current, and pull-out torque.

As computers become available with larger stores and more rapid access, then it will gradually become more economic to let the computer select more variables from stored data, i.e. to let it evaluate a greater number of designs and select the best from a wider choice.

BETTER DESIGN METHODS

Many of the choices of variables which face a designer are, in themselves, vast problems involving many factors. The computer can now be used to assist him in selecting the best few choices of the particular variable, which he can then use as part of the input data to the computer to obtain the characteristics, as described above.

One such factor is the design of three-phase a.c. fractional slot windage.

Such windings, which increase the numbers of slots that can be used, are of considerable economic value. Lack of knowledge of their characteristics have caused them to be misused in the past and they are only now gaining popularity again. They must be designed to give balanced fluxes, convenient end-winding connections, and produce desirable winding factors for all the harmonic and sub-harmonic fluxes which are of importance.

The two and four-pole sub-harmonics are of considerable importance as they can produce excessive mechanical vibrations in some frame structures.

Fig. 1 illustrates how the slot vector diagrams can be produced graphically for N slots for a two-pole and a four-pole distribution, and in a similar fashion for higher orders. A simple form of tabulation is indicated which indicates the nature of the end-connections and also enables the winding factor for any order harmonic or sub-harmonic to be obtained for any choice of slots, and enables the most suitable arrangement to be selected.

So far consideration has been given only to the use of a computer to perform the routine design calculations normally performed by a designer. However, the time required for a computer to perform the calculations associated with the more elaborate and more accurate theories which exist is only a few seconds longer than the simpler routine calculations. The amount of data may be greater but the fact that more realistic characteristics can be obtained will justify the use of the more accurate design method.

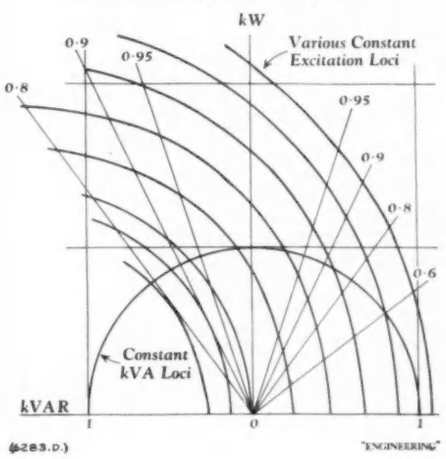
A typical example of this is the use of increasingly complex equivalent circuits in the analysis of the starting of synchronous motors. The simplest procedure is to represent the machine as a simple single-cage squirrel-cage induction motor, and the result of such a calculation is shown in Fig. 2 (*a*) for machines with high and low rotor winding resistance. However, synchronous motors do not behave as such results would indicate and Fig. 2 (*b*) shows corresponding results obtained from an actual experimental machine on test. The shape of the theoretical low-resistance curve is reasonably similar to the test results but for the high-resistance alternative it is obvious that the simple circuit is incorrect. A more accurate, but laborious method of determining the torque is available.[1]

The use of a computer has made this new calculation quite feasible as it merely consists of performing a single calculation for a few selected values of slip. In fact it has been possible to elaborate the basic circuits used while still keeping the time required for calculation to a reasonable value. Each conductor of the starting winding circuit can be represented individually together with mutual effects, instead of using a single lumped cage-winding circuit to represent the combined action of all the bars. Investigation can thus be carried out on the differential loading and heating of bars during the starting period and the effect of using combinations of bars having different impedances can be determined with more accuracy.

Another problem which has hampered machine analysis and associated problems in power system analysis is the effect of magnetic saturation. The amount and form of saturation varies with each condition of voltage, power factor, current, speed and excitation of machines and, in general, it has been impracticable to evaluate true saturated characteristics at more than one or two specified conditions of loading. Very elaborate approximate methods have been developed to avoid such calculations but, with the advent of computers, the more accurate calculations can now be performed in a reasonable time.

As an example consider the kW/kVAr characteristics of a synchronous machine. The simplest approach is to use the simple construction known as the " circle diagram," shown in Fig. 3,

Fig. 4 Characteristics of synchronous machines as found by two-axes method and including effects of saturation. This treatment is possible using a computer.



in which the linear scales used give the constant kVA loci as circles and the simple theory used indicates that the constant excitation loci are circles with centre determined by the ratios of V to X*d*. However this only applies to "round rotor" machines and also ignores saturation effects. The usual two-axes method gives a closer approach to the performance of a salient-pole machine, but still ignores saturation. It is possible, however, by elaborating the calculation and dealing with it step-by-step to include the effects of both stator and rotor saturation and also variable leakage flux.[1] Such a calculation previously involved a great consumption of engineering time and was only carried out for a few machines such as large synchronous motors with automatic power factor control. Fig. 4 shows the results of such a calculation obtained from a digital computer. The scale being linear the constant kVA loci are circular but the constant excitation loci are not circular, as would be indicated by the simple circle diagram shown in Fig. 3. One practical application where this programme has already proved of very great value is the predetermination of variable frequency characteristics for synchronous ship-propulsion schemes.

MULTIPLE PROBLEMS

The machine designer is often faced with determining the operation of his apparatus when used in conjunction with associated plant. In the past it has been usual to determine the characteristics of all the items separately and then the characteristics of the combined plant. To simplify the problem of combining several units it was often necessary to try and determine "linear" characteristics, but, unfortunately, this simplification did not give correct characteristics under all load conditions.

A problem of this type is the design of a marine propulsion unit consisting of a diesel engine driving a propeller through an electromagnetic coupling. The diesel engine must operate over a range of speeds, and owing to the irregular nature of its torque effort diagram it is essential that trouble due to torsional oscillation in the shaft system be avoided. The propeller also has an irregular torque characteristic and its effect must also be considered. Finally the electromagnetic coupling members act as flywheels on the shaft systems, as a spring connecting the separate engine and propeller shaft systems, and also as a damper, but these effects all vary with the system mean speed and acceleration and are dependent on electrical characteristics which involve saturation effects. The accurate calculation of the overall characteristics of such a complete electromechanical system is obviously very time-consuming but must be done for every application. Fairly accurate methods of calculation of the separate aspects of the problem are available and a computer can give an accurate solution to the overall problem very economically and accurately.

NEW SOLUTIONS OF OLD PROBLEMS

All the possible forms of improvement in design obtained by using computers so far described have envisaged using existing methods whether simple or complicated. It should be appreciated, however, that all investigations into these problems have been carried out with a view to representing machine performance in such a manner that calculation of characteristics could be carried out in as simple a way as possible. Ideas which involved laborious calculation were not accepted with enthusiasm and ideas which involved new concepts or variables other than the popular conventional ones were not understood by the majority of people and did not therefore come into common usage. This condition will not continue as computers come into increasing use. As an example of this trend, the effect of solid steel parts in the magnetic circuits of machines may be considered. Many approaches have been made to this problem, each restricted to the individual class of machine concerned. The induction starting of synchronous motors (or transient

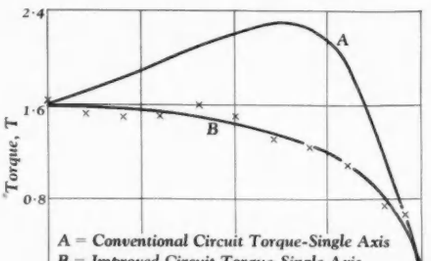


Fig. 5 Torque/slip characteristics of a solid pole synchronous motor, showing the improvement in calculation possible when using a computer.

or unbalanced operation of other machines) having solid steel rotors is one important aspect of this problem frequently encountered. The number of such motors now being built for operation at four-pole speed is increasing and it is most desirable that a reasonably accurate predetermination of starting torque and current should be possible.

Attempts have been made to treat these machines in similar ways to motors with more conventional starting windings.[1] Fig. 5 shows curve (*a*) which uses a conventional single-axis circuit representation with constant rotor reactance and resistance proportional to slip, compared with curve (*b*) which again uses a single-axis circuit representation but assumes that both rotor reactance and resistance vary with the slip. Superimposed are some actual test points on the machine concerned and these show clearly that curve (*b*) is more nearly correct than curve (*a*) but they also indicate the well known two-axes effects and show some of the discrepancies to be expected when using only single-axis representation.

To obtain more realistic results an alternative form of machine analysis can be used, involving the study of the machine by considering the electromagnetic waves in the airgap. This approach can be used for all types of electrical machine and is now being investigated as it sheds much light on problems which cannot be dealt with by the more usual methods and can also be used to demonstrate the normal characteristics. It is thus of great value in giving students and others a more useful conception of machine operation.

The calculation of machine performance using such a method is, of course, somewhat lengthy, and has only been used in a few instances because of the time consumed. However, it is quite possible, by using a digital computer, to obtain these results for a range of variables in a few minutes and this method is now in use. This method of analysis uses the two-axes concept for starting, and by using the "impedance" loci principle in a similar form to that adopted for the more conventional synchronous machine, a reasonably accurate determination of the starting characteristics can be obtained.

CONCLUSION

These simple examples illustrate some of the trends in synchronous machine design which have been accelerated by the availability of the digital computer. It is significant to note, however, that the full power of this device cannot be exploited until a new conception of the electrical machine has been evolved. The classical theories have been derived piecemeal and with a view to representing existing knowledge of performance simply and in an easily calculable manner. Calculating devices, such as analogue computers and simulators, have had only limited success in representing machines as many assumptions had to be made in order to make the problem suitable for such machines.

New theories must be developed to give an efficient basis for future analysis and the factors most likely to simplify this process are, probably, suitable per-unit systems, matrix and tensor methods, and electromagnetic wave theory. The per-unit system is such that it brings any calculation for a range of machines to directly comparable values and makes it very easy to specify the range of all values in the calculation irrespective of the rating of the machines concerned.[2] This simplifies the programming of calculations as it permits the use of the simpler "fixed point" system of working. The use of matrices and tensors in machine analysis has been rapidly developed in the last few years;[3] its advantage being the ability to manipulate large numbers of quantities as easily as a few, and also to generalise electrical machine theory independently of the type of machine involved. It thus enables the solutions of general types of problems to be derived and so simplifies programming as well as teaching the principles of machine chareteristics without involving detailed knowledge of particular machines.

Electromagnetic wave theory appears to be the future method of simplifying the effects of slotting and saliency in machine performance in a simple, comprehensive and accurate manner, but a computer will, of course, be essential to solve the differential equations involved.

It is most important, therefore, that the machine designer of the future should have a general understanding of machine operation and the efficient manipulation of quantities, rather than of specific details of existing design methods, which are usually not of really basic importance or of very great significance.

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SPECIFICATION FOR NEW CABLE REPAIR SHIP

Cable and Wireless Limited are inviting tenders for a new cable ship. She is to be capable of making repairs to telegraph cables and to coaxial cable and rigid repeaters of the type to be used in the Anglo-Canadian telephone cable, to be laid in 1961, and other sections of the proposed round-the-world Commonwealth telephone cable.

The new ship is to be diesel-electric propelled, with a gross tonnage of about 4,000 tons. The overall length will be approximately 367 ft and the breadth 47½ ft; and the cable capacity 21,000 cu. ft. The maximum speed is to be 15 knots.

The ship will have to be fully air-conditioned to enable her to work in tropical waters, as well as more temperate climates, and will have a sea endurance of about seven weeks. She will thus be bigger and faster than CS recorder, at present the largest and fastest vessel in the company's fleet of cableships. Recorder had her maiden voyage in 1954 and has a service speed of 12 knots; an operating range of 10,000 miles and can carry 420 miles of deep-sea cable. Her gross tonnage is 3,300, length 310 ft and breadth 45 ft.

The new ship will replace the two smallest ships owned by the company, CS Retriever and CS Electra. They are 1,500 ton cable repair ships, built for the Admiralty in 1945, and joined Cable and Wireless Limited's fleet in 1948. Their speed is 10 knots and they have a range of one month's voyage, carrying approximately 200 miles of cable. Retriever is based at Singapore and Electra at Port of Spain.

In a description under the title "Swivel Pipe Coupling" on page 621 of our issue of May 8, the cutaway illustration used was of an earlier (Mark 1) unit than the Mark 3 (made by Avica Equipment Limited), the subject of the text.

STREAMLINING A WAREHOUSE

Stocking, packing and despatching of goods is often a problem. When the variety of products and the number stocked become large, and quick service to customers is the aim of the management, the difficulties increase. It was just such a problem as this—great variety of components and assemblies to be stocked in large numbers, and despatched quickly to customers' orders—that confronted Benton and Stone Limited, Aston Brook Street, Birmingham, 6, and when some property adjoining their works came into the market they took the opportunity to acquire the site and erect a new central warehouse for dealing with the whole of the works output.

Benton and Stone manufacture four main groups of product: pneumatic equipment, including valves, cylinders and control gear; centralised lubrication equipment; fittings for the motor trade, such as grease guns and nipples, fuel taps and filters; and solderless fittings and piping. The latter group, of course, is applicable in common with the other three groups, as well as having a market in its own right.

Packed products are discharged from the conveyor automatically at any one of four reception points. Space above the bins is used for storing packing materials

To provide the desired service to customers it is necessary to stock and to be able to despatch quickly some 2,500 different components and assemblies, the individual quantities of each varying between 10 and 500,000. With the new warehouse facilities it is possible to handle customers' orders for standard items on a 24 hour basis; the actual time taken to draw from stock, pack and despatch the goods ordered is often much less, the 24 hour period being regarded as a maximum.

On the site which they took over, Benton and Stone erected a new two-storey building, the top floor being concerned mainly with reception and prepacking of goods from the works, while on the lower floor, which has direct vehicle access to a public road, the main stocks are held, and the final packing is done. Office accommodation is provided on the upper floor for the stock control department, and a mezzanine floor provides storage space for packing materials. Customers' orders are received by the warehouse and despatch instructions are issued accordingly. The warehouse is responsible for ordering stocks from the works in accordance with requirements based on known and estimated demands, and these orders are placed in sufficient time to meet the manufacturing schedules drawn up by the works departments concerned.

PREPACKING

All the components and assemblies produced by the works are taken in containers by motor trucks up a ramp to the upper floor of the warehouse, and delivered to a point adjacent to the appropriate prepacking bench. This operation is directed by a foreman, according to requirements. Containers are then lifted to bench level by means of a plug-in pneumatic lift truck, modified by Benton and Stone from a proprietary foot-operated hydraulic model, and the contents are discharged on to the bench.

Every product is prepacked at this point, the quantities in each package varying, of course, according to the type and size of the individual item. Smaller products are packed in multiples of 100. When the goods have been prepacked and labelled, the packer places the parcels on the tray of a Fisher and Ludlow " Flowlink " pendulum conveyor which runs between the two lines of prepacking benches. This conveyor, which runs continuously, leads to the lower floor. It is fitted with a plug-operated selector system, which enables it to discharge its load automatically at any one of four unloading points. All that is necessary is for the appropriate plug to be pushed in; this is done by the packer as the goods are placed on the conveyor tray.

Every item is prepacked in the new Benton and Stone warehouse, and then loaded on to a conveyor leading to the stock bins.

STOCKING

The major part of the lower floor is occupied by standard Fisher and Ludlow steel bins, grouped numerically about the conveyor discharge points. When a conveyor tray arrives at the point for which the discharge plug has been set, a trip is engaged, and, by means of Benton and Stone pneumatic gear, the tray is tilted sideways. As the tray is actually a short length of roller conveyor, the goods roll off to a short static length of conveyor and so to the point from which an operator unloads them manually. Immediately the station is occupied by goods a red light is illuminated, to warn the operator that attention is needed. If this warning is ignored, and a second tray arrives at the point with its plug set for discharge, a bell rings and the conveyor stops. Clearing the unloading point of goods automatically stops the bell ringing and restarts the conveyor.

The whole of the top row of bins is reserved solely for overflow stock, and records of this stock are kept by the foreman of the department. These bins are not touched by the normal stock operators. If an operator should find one of the ordinary bins empty, it is only necessary to tell the foreman, who will have the stock replenished from the overflow bins. In practice, this position does not often arise, as the foreman makes daily routine checks of the stock position in the standard bins, and has them refilled from overflow stock as required. A date code number is stamped on all prepacked parcels, and care is taken to ensure that the overflow stock is kept moving, so that old stock cannot accumulate.

DESPATCHING

Despatch copies of customers' orders are issued to the warehouse workers, who collect the items required on a wheeled truck from the standard stock bins, and take them to a checker. After checking, the consignment is taken, still on the truck, a short distance to a packing point, where it is packed according to the instructions on the despatch copy of the order, for postal delivery, for export, or for internal delivery by road or rail. Packed consignments are loaded to vehicles by means of a portable power-driven inclined elevator.

A mezzanine floor is formed over the tops of part of the lines of bins, which are designed as load-bearing members, and this serves for the storage of cartons, paper and other packing materials. On its return journey from the lower to the upper floor the conveyor passes over the mezzanine floor, and packing materials are loaded to the conveyor trays for transport to the prepacking benches above as required.

Provision was made in the original design of the bins for the mezzanine floor to be extended if necessary, and this extension is now being carried out.

WELFARE IN THE FOUNDRY

Progressive foundry managements have anticipated the recent legislation dealing with foundry working conditions and the emission of smoke and dust, and equipment for these purposes has long been on the market.

At the Foundry Exhibition at Birmingham (see page 722) George Green and Company, 26 Devonshire Street, Keighley, provide details of their water quenched cupola spark and dust collector, and W. C. Holmes and Company Limited, Turnbridge, Huddersfield, have on exhibition an example of the Holmes-Schneible multi-wash system, which has an efficiency in the region of 99 per cent for all particles above 3 to 4 microns.

A range of equipment shown by Dallow Lambert and Company Limited, Thurmaston, Leicester, includes a wet deduster available in 13 sizes from 2,000 to 48,000 cu. ft per min, and a " Dustmaster " unit, which, by reason of its standardised design, can be built up into 120 different sizes.

EQUIPPING AND RUNNING A FOUNDRY

The Foundry Exhibition, Birmingham

In the foundry industry, as elsewhere, the emphasis is on mechanisation and on the employment of new techniques and materials as well as new machines, and in the search for methods of cost reduction combined with quality maintenance. This is the principal theme of the Foundry Exhibition, which opened on 21 May at Bingley Hall, Birmingham, 1, and closes tomorrow, 30 May. Promoted by the Foundry Trades' Equipment and Supplies Association, the exhibition is the first of its kind to be held in the United Kingdom, and nearly 100 of the leading suppliers of foundry plant and materials have put their products on show.

Foundry work can be divided into three main branches; moulding, melting and casting, and finishing. Supplementary to the business of furnishing machinery and equipment for these main branches are the supplying of metals and materials used in the foundry, and the provision of welfare facilities. All these items are represented at Bingley Hall, and everything the foundry industry needs can be supplied by one or more of the exhibitors.

MOULDING

To the older greensand, drysand and loam moulding processes there have been added, in more recent years, shell moulding and the CO_2 process, and all these methods are in regular use; the newer ones supplementing rather than superseding, the older. Loam moulding does not find the application it used to do in the past (though it is still practised), but all the other processes are widely used.

Makers of machines for sand moulding have produced some new designs, introduced at the exhibition, and shown there publicly for the first time. One of the machines thus given its first British exhibition showing (though it has been on the market in this country for some time), is the Taccone diaphragm moulding machine, made by Baker Perkins Limited, Hebburn-on-Tyne. This machine has already been described in these columns (ENGNG., 7 July, '58, p. 30); the actual moulding pressure is applied by means of compressed air acting on a rubber diaphragm, that the machine can be made in virtually any size, and that it is easily incorporated in a fully-automatic moulding layout.

The SJ5 shockless jolt squeeze moulding machine, taking boxes up to 4 ft long by 2 ft 6 in wide, and the " Blo-shooter," a dual-purpose machine capable of blowing or shooting cores or moulds, both appear on demonstration for the first time at the exhibition. They are made by Pneulec Limited, Mafeking Road, Smethwick, and are additional to the extensive Pneulec range, which includes equipment for sand preparation as well as moulding machines.

Automatic moulding machines shown by the British Moulding Machine Company Limited, Faversham, include a model producing complete, paired-up moulds in boxes 22 in by 16 in by 7 in, and a fully-automatic turn-over device for inverting and placing the drag half mould on a conveyor; this latter is shown for the first time. Similarly, the " Blo-flex " automatic moulding machine, exhibited by J. W. Jackman and Company Limited, Blackfriars Road, Manchester, 3, together with a range of other moulding machines, is of novel design and operates without shock and almost without noise. A pattern shuttling device can be fitted in suitable circumstances to enable the machine to make cope and drag half moulds alternately.

For larger moulds the sandslinger is a well-established machine. This type is represented by a new pattern, the " Servo-slinger," made by Foundry Plant and Machinery Limited, Cook Street, Glasgow, C5. The Servo-slinger retains the basic design of the sandslinger, but has a new servo control system with joystick directional control of the ramming arm. Various sizes of machine are made; that exhibited has a total arm radius of 14 ft and will ram sand at a rate of 36 tons per hour.

An automatic closing machine exhibited by the Floodgate Steel Fabricating Company Limited, 578 Kingsbury Road, Birmingham, 24, deals with moulds 19 in by 17 in by 8 in with a total weight of 500 lb. It eliminates manual lifting and closes boxes at a rate of up to 120 an hour.

Automatic operation is also the outstanding feature of the Hallsworth moulding system, shown by Rubery, Owen and Company Limited, Darlaston. This equipment not only carries out the moulding, but includes a conveyor for closing (or coring and closing), and a pouring conveyor, the whole forming a complete foundry system, which only requires the addition of melting and fettling equipment to enable it to go into production.

A completely different type of machine, that used for pressure diecasting, can conveniently be considered under the heading " moulding." Peco Machinery Sales (Westminster) Limited, 28 Victoria Street, London, SW1, show for the first time at an exhibition one of the latest of a series of three machines designed to meet the present trend towards increased use of aluminium in the manufacture of diecastings. The machine displayed, which has a locking force of 300 tons, is the medium-sized model in the range.

MATERIALS

Moulding materials, such as sands, core oils and binders are well represented, together with plant for material preparation and sand reconditioning. Methods of distributing large or small quantities of CO_2 are demonstrated, together with equipment for applying it to moulds, by the Distillers Company Limited, Piccadilly, London, W1, and an associated company, British Resin Products Limited, of the same address, features " Cellobond " synthetic resins for the shell moulding process. Other bonding materials include two grades of " Fullbond," shown by the Fullers Earth Union Limited, Nutfield Road, Redhill, together with methods of handling and using the material. Bentonite and zircon sand are exhibited by F. W. Berk and Company Limited, Portman Square, London, W1, who also have some new products on show, including " Petro-bond," a sand binder for precision casting with conventional equipment, and some new CO_2 materials.

Shell moulding and casting are represented by a machine—one of a range—shown by the Fordath Engineering Company Limited, Albion Road, West Bromwich, and by the German made Henschel mixer, displayed by Foundry Suppliers Limited, 25a Cockspur Street, London, SW1. This latter exhibitor also features the Swiss made sand testing equipment produced by Georg Fischer, A.G. and the German " Hygrotester," which is designed for automatic moisture control of moulding sand. Shown for the first time in this country is the new Dietert universal sand strength testing machine. Exhibited by Ridsdale and Company Limited, Newham Hall, Middlesbrough, this machine has a higher capacity than the old model, testing in compression to 520 lb per sq. in, tensile up to 620 lb per sq. in, and transverse up to 370 lb per sq. in.

Metals and alloys are available in great variety today, and the exhibition shows this development fully. Bradley and Foster Limited, Darlaston, for example, have a large range of refined irons in both sand cast and machine cast pigs, and similar products are displayed by G. and R. Thomas Limited, Bloxwich. Similarly, Union Carbide Limited, 103 Mount Street, London, W1, supply about 150 different alloys and metals for iron, steel and non-ferrous foundries, and these products are exhibited.

MELTING

Two of the most important developments in the metal melting field in recent years have been the introduction of the hot blast cupola and the widespread extension of electric melting.

An independently fired cupola blast heater exhibited by the Incandescent Heat Company Limited, Cornwall Road, Smethwick, uses oil fuel and reaches the working temperature of 500° C in 30 min from starting. The model displayed is suitable for supplying hot blast to two 4 ton per hr cupolas. Complete cupola plants, with automatic charging gear and oil-fired hot metal receivers are also the subject of display by this exhibitor. Hot blast equipment is likewise one of the principal exhibits of Fuel and Metallurgical Processes Limited, 21 St. James's Road, Dudley, who have, among other products, a new steel tube convector unit with a thermal efficiency of 85 per cent. This unit is very easily installed, and is particularly suitable for use with small cupolas on short runs.

In the electric furnace department, Birlec-Efco (Melting) Limited, Aldridge, a newly-formed company combining the electric melting interests of two well-known concerns, make their first appearance at an exhibition. They have on show two furnaces from their range; a self-contained high-frequency induction melting unit and a holding furnace for aluminium and zinc-based alloys; the latter is intended for use with a diecasting machine. Two crucible furnaces are featured by the Morgan Crucible Company Limited, London, SW11; one is an oil-fired bulk melter and the other the Birlec Morgan electric diecasting furnace.

FINISHING

Dressing and finishing of castings starts with the shakeout of the solidified casting from the mould. In mechanised plants and for most smaller castings this is usually done by a machine which vibrates the box and breaks up the sand, leaving the casting free. Shakeout machines are shown by Sterling Foundry Specialities Limited, Bedford. Two machines are displayed, an 8 ft by 6 ft, 10 ton machine and a similar one of smaller capacity, 4 ft by 3 ft.

A certain amount of hand finishing of castings is still necessary, and probably always will be, but machines are used today on a very large scale.

Where hand fettling is needed the use of a specially designed fettling bench, with built-in dust extraction equipment is highly desirable; Newton Collins Limited, Barford Street, Birmingham, 5, exhibit such a device. The bench is provided with two extraction slots, one along the front and the other at the top of the raised back, giving air curtains above and in front of the work. Light airborne dust, the harmful product of the fettling operation, is thus removed at the source.

For cleaning castings in quantity shot blasting is now a firmly established process. Suitable equipment is exhibited by Tilghmans Limited, Broadheath, Altrincham, who have on show their 7 cu. ft capacity " Autoblast " wheel type machine, a 9 ft rotary table and a barrel machine. Representative heavier machines are featured by H. G. Sommerfield Limited, 8 Camden Road, London, NW1; these include heavy duty compressed air plants capable of dealing with Centurion tanks. Similarly, blast cleaning rooms are demonstrated by Spencer and Halstead Limited, Osset.

LARGE SCALE FABRICATION

Special Provisions Include Ultra-Clean Assembly

Extensions at the Derby works of International Combustion Limited provide production facilities for the largest and heaviest pressure vessels and other heavy engineering assemblies required at present or in the foreseeable future, both for conventional and nuclear power plant, and for the chemical and oil refinery industries. In addition, provision is made for the ultra clean assembly of large heat exchangers and other equipment required for nuclear work—a development which is relatively new in the heavy engineering field, but one of increasing importance.

The extensions recently opened formally by the Minister of Power, Lord Mills, consist of a heavy engineering shop, a "clean conditions" building, and improved materials preparation equipment. At the same time the laboratories have been extended and the research facilities rationalised in order to keep abreast of technical changes.

Materials, received by road or rail transport, are unloaded by overhead travelling crane to a stockyard adjoining the new engineering shop, and transferred by rail bogie into the shop as required. For plate edge preparation there is a Hancoplane flame planing machine installed in a separate building at the engineering shop end of the stockyard. Plates are loaded on to a cable hauled bogie which is push-button controlled by the Hancoplane operator, and run into the preparation building. Here all four edges can be prepared simultaneously for welding, the machine being capable of three-cut bevel preparation of plates up to 11 ft wide, 40 ft long and 4 in thick. After flame planing of the edges the plates are run into the engineering shop on the same bogie.

The new heavy engineering shop of International Combustion Limited caters for preparation, welding and heat treatment of large pressure vessels and other heavy products.

Edge preparation of the "J" type, and machining of the edges of partly-formed vessels is carried out on machines in the main shop.

The main extension to the works is in the form of a heavy engineering shop of 68,250 sq. ft area, built on concrete piles, and arranged in three bays, a centre bay 75 ft wide and two wings each 65 ft wide; the overall length of the shop is 350 ft. Each bay is served by two overhead cranes, the largest having a lifting capacity of 50 tons, and to allow for work on large pressure vessels, the crane rails are 40 ft above ground level.

A pit in the centre bay, 150 ft long, 25 ft wide and 12 ft deep, allows very large diameter vessels to be assembled and welded, manipulating equipment being provided on the pit floor for rotating vessels during seam welding. A screened space is also provided for X-ray examination of welds.

Machines are arranged mainly round the perimeter of the shop, allowing for manufacture to proceed in progressive stages. Movement of material arriving from the stockyard or the Hancoplane edge preparation machine proceeds along the side of the shop to Craig and Donald 12 ft by 1½ in plate bending rolls, a Hugh Smith 35 ft edge planer or a Craven 8 ft by 8 ft by 25 ft planing machine, as required. Plate ends are pre-bent ready for cylindrical rolling in a Fielding and Platt 2,000 ton downstroking hydraulic press.

Heavy plate bending is done in one of two Fielding and Platt vertical hydraulic roll type presses of 3,000 tons capacity. One of these machines will bend plates 10 ft wide and up to 2¾ in thick to a minimum diameter of 6 ft and up to 4 in thick in larger diameters. The other press will deal with plates 15 ft wide and 3 in thick to a minimum diameter of 3 ft cold. It will bend plates of the same overall dimensions and up to 5 in thick to a minimum diameter of 5 ft when hot.

Edge preparation for circumferential welding can be done after bending on an 8 ft by 30 ft Hulse centre lathe, or on an 18 ft George Richards vertical boring machine, which is equipped with outriggers to enable it to take work up to 25 ft diameter. This machine can also be used for general turning and facing, and has a speed range which enables it to be used with a flame cutting head.

The principal welding machine is a Quasi-Arc automatic boom welder with a rising boom catering for vessels up to 12 ft 6 in diameter and 50 ft long. A roller bed enables the vessels to be rotated or traversed to produce circumferential or longitudinal welds.

Solus-Schall and Newton Victor units provide for X-ray examination of welds. After welding the complete vessels can be heat treated in a Dowson and Mason gas-fired stress relieving furnace 14 ft wide, 12 ft 6 in high and 24 ft 4 in long, or in a similar furnace of the same make 8 ft wide by 9 ft high and 40 ft 8 in long.

A Dowson and Mason plate heating furnace is grouped with the stress-relieving furnaces, and arranged to face the hydraulic downstroking press used for plate edge bending or dishing.

After welding and stress relieving further machining can be carried out as required, either on the machine tools already mentioned, or on a range of standard machines which covers all the requirements of the shop. Pressure vessels are then ready for despatch, but equipment requiring "clean" assembly passes to the adjacent clean conditions building, where final assembly is carried out in isolated booths, supplied with filtered air, and where stringent conditions of cleanliness are imposed on equipment and workers alike.

North American Sales

Success in the North American market has come to many firms over the past year or so—in fact since the US depression—who had struggled almost continuously since the war with very little to show for it. Price now appears to be a more weighty factor than it was and the relatively low British prices are attracting buyers. R. W. Crabtree recently obtained an order in Canada worth $650,000 for a large printing press, "against considerable competition, chiefly from America." The chairman of the company, Mr. Charles Crabtree, visited New York, Detroit and Chicago, "as a preliminary move to more activity in the United States."

There is also a growing interest in British-made products in the United States. An example of this is provided by Corning Glass Works, America's largest manufacturers of technical glassware, who have just entered into an agreement with QVF Limited of Fenton, Staffs., to distribute the latter's products in the United States. The manager of Corning's plant equipment sales division, Mr. W. H. Tomb, said that he was impressed by "the extent to which the British glass industry is meeting the needs of the chemical and pharmaceutical industries and the extent to which they ensure that all accessories are available, even to the manufacture of supporting frames and control equipment."

Canadian manufacturers are likewise finding a new interest in British products. The British engineering display at the Canadian National Industrial Production Show in Toronto made an excellent impression. The joint sponsors—the Board of Trade and the Birmingham Engineering Centre—and the 30 firms which took part were well pleased with the interest shown by Canadian and American business representatives. One of the United Kingdom exhibits, a number three Kearns patent electronic universal horizontal surfacing, boring, milling, drilling, tapping and screw-cutting machine, with a British Thomson-Houston automatic coordinate setting and depth control, weighing 33 tons, with its own computer, is able to undertake all kinds of borings of large pieces of metals to an accuracy of ± 0·0002 in. Like taking coals to Newcastle, perhaps, but nonetheless most impressive evidence of British engineering inventiveness and skill.

South American Sales

British cars are to be made in the Argentine. The British Motor Corporation have signed an agreement with SIAM Di Tella of Buenos Aires for the "progressive manufacture" of their vehicles. In their announcement, BMC recall that for two years after the war, in 1946 and 1947, over 7,500 Austin and Morris vehicles were exported to Argentina, representing over two thirds of all exports from the British motor industry to this market. Subsequently, restriction of imports killed the market.

In the initial stages 1½ litre cars and light trucks and vans will be involved. SIAM Di Tella are the largest engineering company in South America, employing over 15,000 people and producing a wide range of engineering equipment ranging from refrigerators and Lambretta scooters to heavy electrical machinery and steel piping.

Success is also being achieved in South America by Marconi's Wireless Telegraph Company. Their latest order is for complete transmitting and studio equipment, worth £250,000, for a new station which is under construction at Recife, Pernambuco.

Further evidence of the Continual building up of the industrial potential of South America was provided by Reynolds Industrial Incorporated, the overseas operating subsidiary of Reynolds Metals Company, Richmond, Virginia. They have selected the Valencia area in Venezuela for the construction of an aluminium extrusion plant, to be followed by an aluminium sheet and foil plant and foil converting facilities.

The total investment will be approximately 20 million Bolivars ($6 million) of which half will be represented by capital stock which will be offered in the open market.

Driving Dollars Abroad

Considerable incentives will be offered to American businessmen for investing abroad if the "Foreign Investment Incentive Tax Act of 1959," now before Congress, should become law. An article by Congressman Hale Boggs, chairman of the House of Representatives Subcommittee on Foreign Trade Policy, is published in the current issue of *Anglo-American News* (vol. 26, No. 5, May, 1959), dealing with the background, aims and the political and economic philosophy behind the Bill.

Commenting on the valuable but temporary contribution made to Europe's anti-communist front by Marshall Aid, Mr. Boggs notes: "it should be apparent to all that something more dynamic and less artificial must now be employed to develop the economic resources of all countries outside the communist orbit." His Bill proposes substantial tax incentives to foreign investors. Its cornerstone is the provision for a new class of domestic corporation to conduct the foreign operations of American firms. Such "foreign business corporations" would be permitted to retain the earnings derived from foreign operations "for use in the expansion of foreign investment and trade activities without any immediate payment of US tax." Tax would be paid only when income is withdrawn from foreign operation.

There would in consequence be no need for United States firms operating abroad to abandon the United States flag and operate under the flag of a taxless state. It would enable United States companies to take advantage of "tax paring" measures taken by many of the Governments of underdeveloped areas for fostering private investment. It would eliminate double taxation in every case. Calling for such an alternative to "the indefinite continuation of $1,500 million to $2,000 million a year in appropriation for foreign economic aid and technical development." Mr. Boggs suggests that Americans might well teach the dynamic character of the free enterprise system "by demonstrating directly how it works."

Teaching Salesmen

A three-year training course for sales engineers, at a cost of £2,000 per trainee, is operated by Newman Industries Limited as one of the keystones in their plans to expand sales. In the past three years Newman's have more than doubled their sales of electric motors. They are now establishing new area offices at Newcastle upon Tyne and Cardiff, to increase their outside sales facilities by some 50 per cent.

A sales drive in North America is headed by Mr. A. J. Newman, chairman and managing director, who recently flew to his New Jersey headquarters in the United States and has been joined there by Mr. Charles Bush, director and secretary of the company, and Mr. Colin Bedale-Taylor, their methods and development engineer. Newman's entered the United States market in 1952 and formed a sales company, Newman Electric Motors Incorporated, who now have 21 district offices and 300 distributors throughout the United States. Exports account for over 60 per cent of the company's turnover.

At Home

PLUG IN ANYWHERE

Standard Electrical Supply

In the good old days of private enterprise when every town proudly set up its own electricity generating station (and some of them were things of real beauty) each chose a supply system to the fancy of the engineer appointed. Direct current, alternating current, 50 cycles, 25 cycles, 250 volts, 110 volts, 440 volts—the lot. All very nice till you tried to move house and found that most of your apparatus would not work in the new home.

Over the years, since standardisation of supply at 50 cycles was provided for in the Act of 1926, the authorities have plodded on with the work of conversion. Frequency of a.c. supplies was virtually completely standardised by 1939, just before the outbreak of war, but not so with voltages. Indeed, it was not till after the war that standard voltages were actually prescribed. Even now, some 12 years later, there are still 13 per cent of consumers on a.c. systems running at voltages below the standard of 230-250V, and still 2 per cent who are on d.c. Area Boards claim that "post-war restrictions and financial stringency" have prevented them from proceeding faster with the work. Meanwhile the unfortunates—and there were 2,135,000 of them in 1958—continue to have to buy non-standard appliances that they may have to abandon if ever they move house. It is good to read that the Boards are at last proposing to speed up the completion of the work.

One reason for this decision is that the cost of the changeover tends to increase as the years pass. The consumption of electricity doubles every ten years. This means that the non-standard generating plant has to cope with vastly increased loads, and is nearing the end of its useful life anyway. Obviously, therefore, it is a better proposition to replace it with standard plant than to install non-standard equipment again, and then take it out after a few years. It also means that consumers are buying more appliances and therefore the cost of making these suitable for the changed supply is also increasing. Not really surprising therefore that the Board want to hurry matters on. As hurrying them on also suits the consumer, both sides should benefit if an all-out drive is made. It would also relieve the manufacturer from one of his minor headaches—that of having to make non-standard appliances.

Most of the advantages of a standard supply throughout the country are pretty obvious. Equipment and appliances can be used anywhere, towns can be linked together so that one station can feed several; in the event of a breakdown in, say, Dover, a supply could still be maintained there from another station—in Scotland if need be.

Wider still, one country can help another by a direct link-up of their grid systems. (The crossing of the Channel has been a stumbling block between this country and Europe, and the exchange in this case will have to be by direct current.) Another point that affects the consumer particularly is that a really national system implies a national scale of charges, and, as in the case of postal services, the cost of overheads can be spread, and spread thinly.

In the home itself there is a fruitful source of annoyance that would be almost completely eliminated by standardisation—the plug and socket muddle. There are square pins, round pins, split pins, solid pins, three pins, two pins (is there a one pin? It would not be impossible), not to mention 2 amp, 5 amp, 13 amp, and 15 amp sizes. Granted that newer houses and all being built now use the ring wiring system and the three (rectangular) pin 13 amp fused plug as standard, but all the others are still on the market, apparently without any restriction. So the confusion is likely to continue for many years to come.

It is surely convenient to have all plugs in a house the same size, for then only one pattern has to be bought and any appliance fits any socket. Yet there is much to be said for having definitely different sizes for appliances that draw widely different currents. In the case of pre-ring wiring (that is in about 90 per cent of all existing houses) difference in size is essential if proper fusing is to be maintained. Thus a 2 kW electric fire accidentally plugged into a circuit wired for 5 amp is liable to cause trouble which would have been prevented if the plug had been 13 amp size. (The deliberate use of the wrong size plug is quite another story, on a par with the use of a hairpin fuse.) The opposite fault—plugging an appliance with a maximum rating of ½ amp into a 15 amp circuit—can also cause trouble but not quite so immediately.

These older circuits rely on fuses mounted in a (sometimes) central board, each more or less carefully labelled. With the ring, the appliance fusing is in the plug and the whole circuit relies for its protection on a 30 amp fuse or a circuit-breaker. Pity the poor electric clock (normal rating 0·1 amp, say) on which a short develops if the plug it uses is fused for the full 13 amp. It could get rather hot! It therefore becomes vital that the fuse in the plug should be chosen to suit the appliance it serves—but how many householders are sure of this? Certainly if the fuse were too small they would find out soon enough, but if it were unjustifiably large, damage and fire could easily result before the fact was realised. Once in the plug, the fuse is invisible; from the outside there is no means of telling what the capacity may be (except in the brand which has a pointer that can be set to the fuse rating—if you remember to do it). And how many wiremen, professional or amateur, really bother to check the fuse rating when first they attach the plug?

A possible compromise is the fused adaptor in conjunction with smaller plugs for low rating appliances. But inevitably some of the interchangeability is lost, for the adaptor must always be found before you can plug in.

Apart from the complete interchangeability, the great advantage of the fused plug is that, should the fuse blow, only the one piece of equipment is affected, you are not left entirely in the dark, searching (*a*) for a candle, (*b*) for the fuse wire, and (*c*) for the fuse box. Use of a switched socket is strongly advised as you can draw a very respectable arc pulling out a plug carrying 10 amps.

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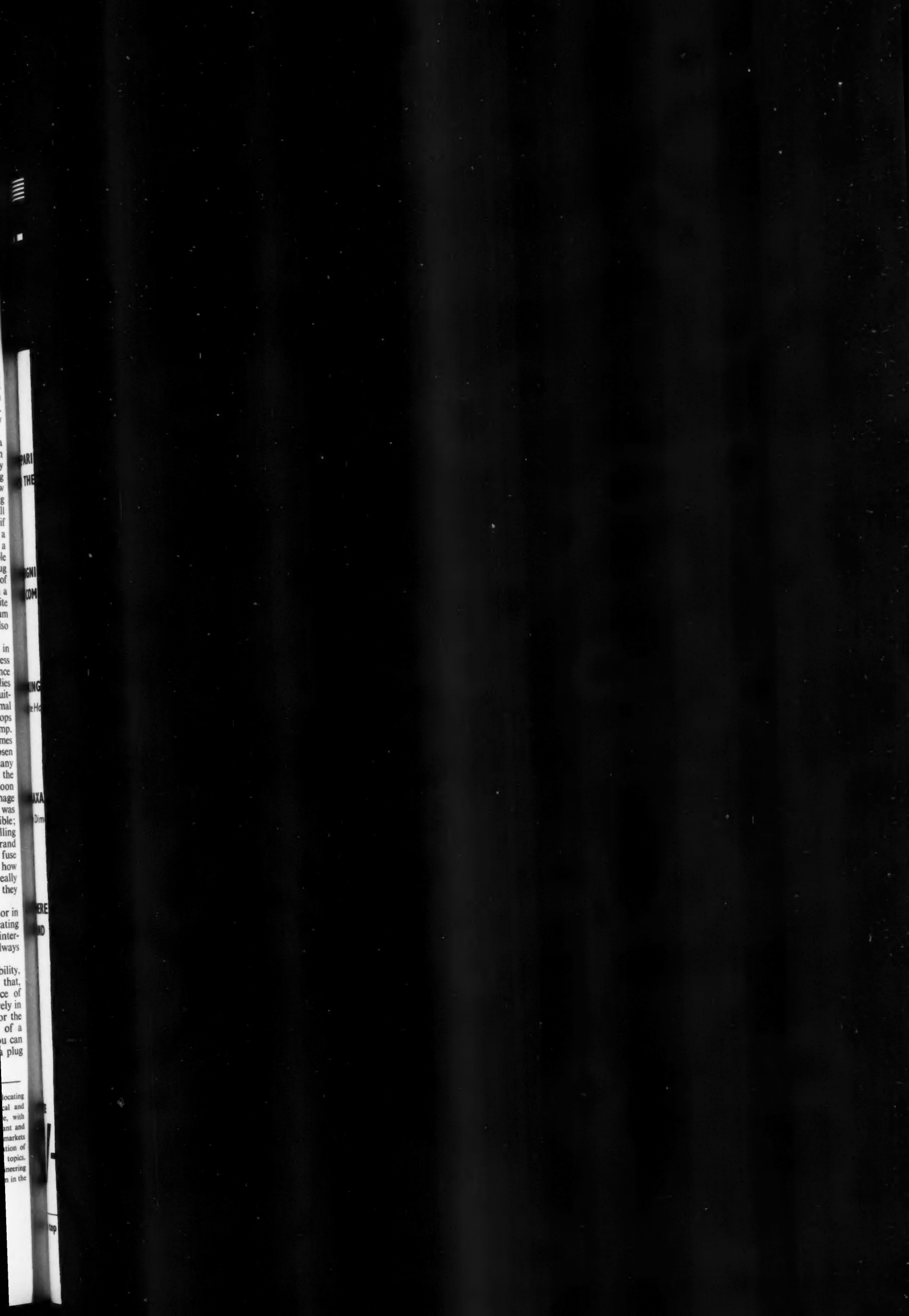
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